JUL 14 1930

AGRICULTURAL ENGINEERING

The Journal of the American Society of Agricultural Engineers

JUNE 1930

Dynamic Properties of Soil Affecting Implement Design - - - - *M. L. Nichols*

Composite and Solid Steels for Tillage Implements - - - - *McMillen aud McIntosh*

Influence of Head on Water Movement in Clay Soils - - - - - - - - *C. W. Botkin*

Relation of Machinery to Maintaining Soil Fertility - - - - - - - - *C. A. Bacon*

Strength Tests of Sewed and Riveted Leather Splices - - - - - - *J. Grant Dent*

Cement Stucco as a Decorative Building Material - - - - - - - - *W. G. Kaiser*

VOL. 11. NO. 6

THIS IS NUMBER NINE OF A SERIES OF ADVERTISEMENTS TO COLLEGE MEN

Additional FARM PROFITS

NEARLY 80 percent of the cost of raising grain has been invested when the grain is harvested. All this investment, plus the profit and to some extent the condition of the land for future crops, depends on how well and how quickly the threshing is done.

With a Case Thresher, the farmer can get his grain to market in better condition. He can clear his fields and get his fall work done very much earlier. He can save enough grain to pay for the machine in a few seasons. He can do the threshing for some of his neighbors at a clear profit for himself.

The Case threshes all grains and seeds fast, clean and without waste. It is fire-proof, weather-proof and requires little expense or work in upkeep. It lasts for years. Many of the first Case steel threshers, built in 1904—26 years ago—are still in use, and today's machines are even more durable.

The Case Thresher is simple, easy to operate. It can be operated with the minimum of power. Because of all these advantages, there are more Case Threshers in use than any other three makes combined.

A complete description of Case Threshers will be gladly furnished.

Est. 1842 CASE

The Greater Case Line includes a machine for practically every farm purpose

J. I. CASE CO., Inc., Dept. F-2, Racine, Wis.

CASE

QUALITY MACHINES FOR PROFITABLE FARMING

AGRICULTURAL ENGINEERING

Published monthly by the American Society of Agricultural Engineers
Publication Office, Bridgman, Michigan. Editorial and Advertising Departments at the Headquarters of the Society, Saint Joseph, Michigan

Subscription price to non-members of the Society, $3.00 a year, 30 cents a copy; to members of the Society, $2.00 a year. Postage to countries to which second-class rates do not apply, $1.00 additional. Entered as second-class matter, October 8, 1925, at the post office at Bridgman, Mich., under the Act of August 24, 1912. Additional entry at St. Joseph, Mich. Acceptance for mailing at the special rate of postage provided for in Section 1103, Act of October 3, 1917, authorized August 11, 1921. The title AGRICULTURAL ENGINEERING is registered in the U. S. Patent Office.

W. G. KAISER, President — RAYMOND OLNEY, Secretary-Treasurer

Western Advertising Representative: J. C. Billingslea, Inc., 123 W. Madison St., Chicago, Ill.

Vol. 11 — JUNE, 1930 — No. 6

CONTENTS

DYNAMIC PROPERTIES OF SOIL AFFECTING IMPLEMENT DESIGN 201
By M. L. Nichols

COMPOSITE AND SOLID STEELS FOR FARM TILLAGE IMPLEMENTS 205
By R. H. McMillen and F. F. McIntosh

INFLUENCE OF HEAD ON THE MOVEMENT OF WATER IN GILA CLAY AND GILA CLAY LOAM 209
By C. W. Botkin

ELECTRIC HAY HOISTS 212
By E. W. Pilgrim

RELATION OF FARM MACHINERY TO MAINTENANCE OF SOIL FERTILITY 213
By C. A. Bacon

COMBINE PERFORMANCE IN GERMANY 216
By Nordahl Wallem

STRENGTH TESTS OF SEWED AND RIVETED LEATHER SPLICES 217
By J. Grant Dent

RURAL LINE CONSTRUCTION 218
By F. la T. Budgett

STUCCO AS A DECORATIVE BUILDING MATERIAL 219
By W. G. Kaiser

THE ELECTRIC BROODER AS AN IDEAL POWER LOAD 222
By A. J. Van Schoick

AGRICULTURAL ENGINEERING DIGEST 223

WHO'S WHO IN AGRICULTURAL ENGINEERING 225

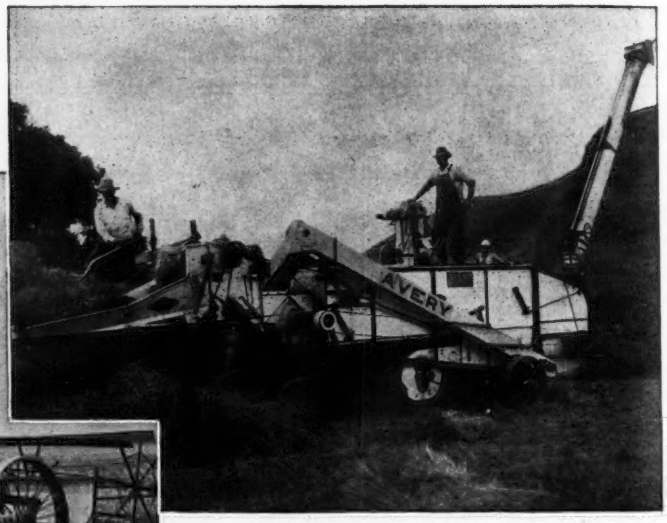
EDITORIALS 226

A.S.A.E. AND RELATED ACTIVITIES 227

FARM machinery runs freer, runs longer, and runs more economically on Hyatt Roller Bearings. More power at the draw bar or belt and less attention to lubrication.

In Avery threshers and combines, for example, sturdy Hyatts do their work of conservation steadily for years, and require no time out for adjustment or repair.

On the farm, HYATTS are everywhere



(*Above*): Avery Thresher. (*At left*): Model B Avery Combine at work in Kansas. Both machines were built by the Avery Power Machinery Co., and thoroughly protected with Hyatt Roller Bearings.

In modern oil tight, dust proof housings no foreign matter can enter to null their flawless operation.

Rugged strength, long life, smooth performance, capacity to withstand strains and shocks . . . these are characteristics inherently Hyatt.

Most prominent manufacturers of power farming machinery use Hyatts to give farmers many extra years of carefree bearing performance.

EQUIPPED WITH HYATT ROLLER BEARINGS

HYATT ROLLER BEARING COMPANY

Newark Detroit Chicago Pittsburgh Oakland

HYATT ROLLER BEARINGS

PRODUCT OF GENERAL MOTORS

AGRICULTURAL ENGINEERING

Vol. 11 JUNE, 1930 No. 6

Dynamic Properties of Soil Affecting Implement Design[1]

By M. L. Nichols[2]

SOIL dynamics and tillage have been listed by the Research Committee of the American Society of Agricultural Engineers for the formulation of a program of research in mechanical farm equipment as two of the most important and necessary subjects to be investigated by the Society[3]. The general object of soil dynamics studies is to furnish a basis for implement design by determining the reactive properties of soils to applied force. It is possible, of course, to determine the gross reaction of any specific soil to any specific implement by means of a dynamometer, but since the soil is constantly varying in moisture content and since the implement usually contains a number of design variables, an endless amount of testing would be required to determine the effect of all possible combinations. Consequently, the logical method of procedure is to determine what soil and implement variables enter into tillage problems and the interrelationships of these variables.

The second objective is to devise simple tests by which soils can be compared or their reactions accurately predetermined. Such determinations would make possible a very valuable classification of soils.

The object of the work on soil dynamics may be shown more specifically by listing as questions some of the problems which can be solved, in whole or in part, by means of the information sought, as follows: What design of plow bottom is best adapted to push soils? What plow will accomplish a given objective with the least draft? What advantage has an inclined landside over a straight side? What is the increase in draft due to dull points? What sized wheel and width of tire is most desirable for a given load on a given soil? What is the relation of weight of planter and size of planter wheel to crust formation? What type of grouter on a binder or mower gives the maximum driving power with a given weight?

Variables. The first step in this study, the determination of the variables affecting implement design, has already been carried out and the results published[4]. The difficulties usually encountered in this work were largely due to the fact that all soil movements, except those on the surface, were invisible. This difficulty was overcome by running a plow through the soil in a box provided with a plateglass window, which gave another plane of observation, and by putting pieces of thin aluminium foil in the soil so that movements of its parts could be accurately determined by stopping the implement at any desired place. In some cases movements of the soil were permanently recorded by plaster casts showing the distortion of various layers[5]. A somewhat similar attempt had previously been made by White[6] using pegs driven in the soil, but the rigidity of the pegs in experiments attempted by the author obscured the exact nature of the soil movements.

The following chart shows the variables entering into these reactions; it is apparent that a knowledge of the interrelations of these elements is what is sought, for they consititute a cause and effect relationship:

Classification Chart
Variables Entering into Soil Dynamic Studies

(Soil Structure, uniform; Cementation, zero)

Primary Soil Factors (Measurable or controllable)	Design Variables (controllable)	Dynamic properties of Soil (measurable)	Dynamic Resultants (measurable)
Particle size	Kind of metal	Coefficient of internal resistance (or shear value)	Fragmentation
Colloidal content	Polish		
Moisture (percentage)	Bearing area	Friction	Arch action
Apparent specific (state of compaction)	Curvature of surface applying force	Resistance to compression	Compaction
Organic matter		Cohesion	Shear
Chemical composition of colloid		Adhesion	
		Moment of inertia	

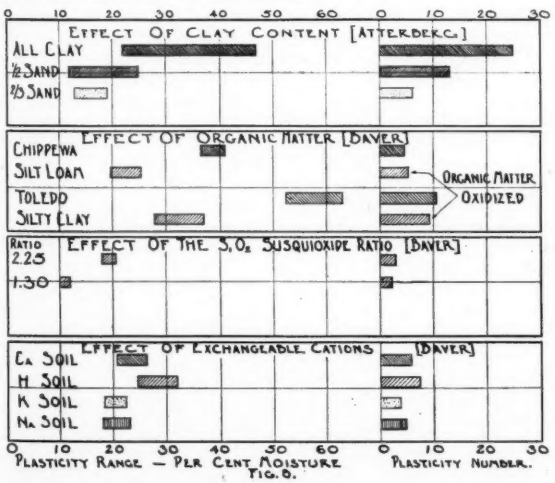


FIG. 6.

[1]Paper presented at a joint meeting of the Southern and Southwest Sections of the American Society of Agricultural Engineers, Jackson, Miss., February, 1930.

[2]Agricultural engineer, Alabama Agricultural Experiment Station. Mem. A.S.A.E.

[3]Walker, H. B. Research in Mechanical Farm Equipment. U.S.D.A. Misc. Pub. No. 38 (1928).

[4]Nichols, M. L. Methods of Research in Soil Dynamics as Applied to Implement Design. Alabama Experiment Station Bulletin 229, May 1929.

[5]Nichols, M. L., and Randolph, J. W. A Method of Studying Soil Stresses. Transactions of American Society of Agricultural Engineers, Vol. 19, 1925.

[6]White, E. A. A Study of the Plow Bottom and Its Action Upon the Furrow Slice. Transactions of American Society of Agricultural Engineers, Vol. 12, 1918.

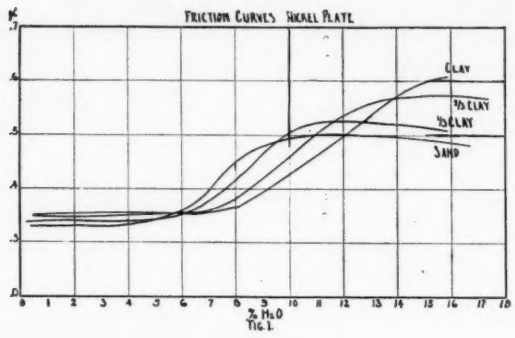


FIG. 1.

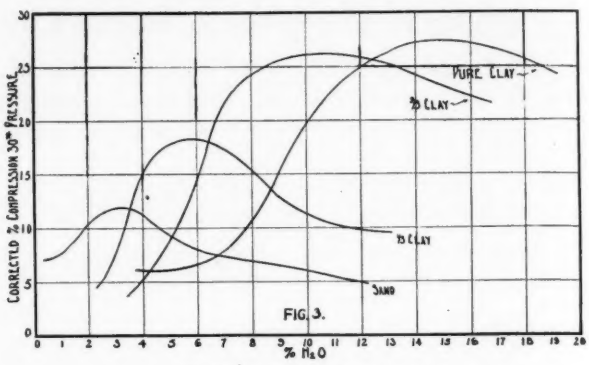


FIG. 3.

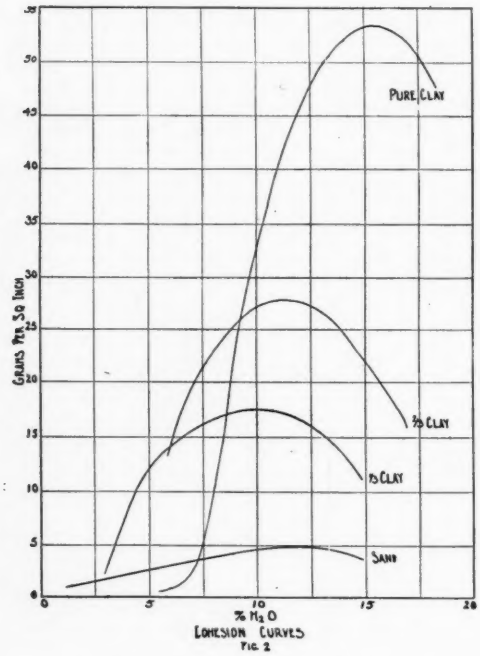


FIG. 2

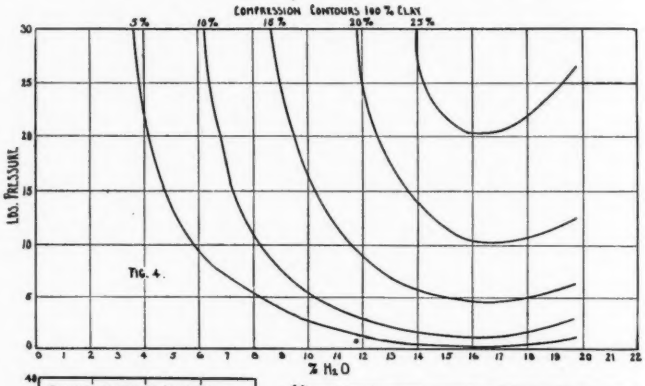


FIG. 4.

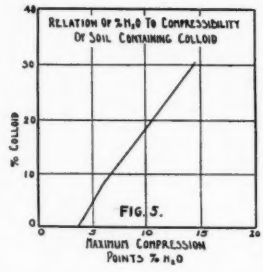
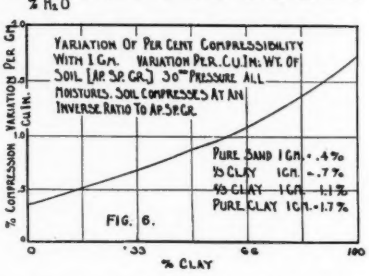


FIG. 5.


VARIATION OF PER CENT COMPRESSIBILITY WITH 1 GM. VARIATION PER CU IN. WT. OF SOIL (AP. SP. GR.) 30" PRESSURE ALL MOISTURES. SOIL COMPRESSED AT AN INVERSE RATIO TO AP. SP. GR.
PURE SAND 1 GM. = .4%
⅓ CLAY 1 GM. = .7%
⅔ CLAY 1 GM. = 1.1%
PURE CLAY 1 GM. = 1.7%
% COMPRESSION VARIATION PER GM. CU IN.
% CLAY
FIG. 6.

A more general classification has been suggested by Haines[1] who considers the mechanical properties of soils concerned in plowing as consisting of (1) soil cohesion, (2) soil plasticity and (3) surface friction between soil and metal. It seems, however, necessary from a design standpoint to divide soil plasticity into shear or internal resistance to movement and resistance to compression, since shear occurs after compression

Dynamic Properties of Soils. The classification of the dynamic properties of soils listed in the chart was obtained by observation of the soil's reaction to a plow. It is evident that these properties are entirely due to the factors listed as "Primary Soil Factors" and that they are closely interrelated. For instance, a curve made by plotting the pull weight ratio (coefficient of friction) against moisture will include both friction and adhesion values. Cohesion enters into shear value, and from a practical viewpoint, is itself affected by the soil's resistance to compression in that it depends as much upon the number of films being pulled apart as upon the strength of the films themselves.

Cohesion is listed by practically all investigators as one of the most important physical properties. There can be no question of its importance as a reactive property, but since it seems to enter into every soil reaction, further evidence may show that shear and resistance to compression sufficiently account for cohesion to warrant its omission from studies of this kind. It is entirely possible, therefore, that this classification may be further simplified, but this cannot be safely done without more evidence than is at present available.

Relation of Primary and Dynamic Variables. The main objective of the studies to date has been to determine the relationships existing between the dynamic properties of soils and the primary soil factors, since it was felt that this was advisable before studying the relationship of these variables to design. The methods of studying these variables have already been published with a sufficient amount of data to allow an appraisal of their value [4, 5, 8].

It has been shown [4, 5] that the colloid content had a decided effect on the dynamic properties of the soil. Further work with soils varying widely in amount and composition of colloid show that the general reactions hold for all soils studied.

The general relation of the primary soil factors, particle size, colloid content and moisture percentage to the dynamic factor is shown in Figs. 1, 2, 3, 4 and 5. In Figs. 1, 2 and 3 the four curves are for the same soils. These soils were prepared by mixing various portions of pure sand with Cecil clay. These synthetic soils varied in

[1]Haines, W. B. Studies in the Physical Properties of Soils. Mechanical Properties Concerned in Cultivation. Journal of Agricultural Science 15, 178-200, 1925.

[8]Nichols, M. L. The Sliding of Metal Over Soil. Transactions of American Society of Agricultural Engineers, Vol. 19, 1925.

colloid content as follows: Clay (Cecil), 32 per cent colloid; two-thirds clay, 21.2 per cent colloid; one-third clay, 10.6 per cent colloid; sand, less than 0.2 per cent colloid. Fig. 4 shows the relation of moisture, pressure and compression in the Cecil clay. Fig. 5 gives the relation of the moisture content at which maximum compression takes place to the percentage of colloid for the four soils. The effect of various kinds of colloid and organic matter will be shown later in the discussion of plastic soils. The factor of apparent specific gravity is held constant, or corrected for, in the data from which these curves were plotted. These corrections are made from determinations of the variation produced by different specific gravities of the soil being tested. Fig. 6 shows a curve obtained from studies of this kind by which all compression studies of the four soils above mentioned were corrected.

At the beginning of this work it was decided that the soil would be studied as a material and that structure would be held uniform. It was felt that, since structure was due to the action of various agencies, it would vary so widely that any results obtained would be qualitative rather than quantitative. Experiments with a number of soils, however, indicate that structure is a sufficiently constant property to warrant quantitative studies. In the laboratory studies of equal pressures produce practically equal apparent specific gravities when applied to two samples of the same soil. Different soils naturally have different apparent gravities when treated alike. If the work of two investigators is compared the results to date show surprising agreement where a considerable range of variation was expected due to various structures. This has been observed in studies of cohesion, shear, compression, arch action, and movement of chisels. From these observations the hypothesis is advanced that each soil normally has a specific structure. Since the forces influencing structural arrangement are the same as those affecting any other action or reaction this does not appear unreasonable.

The next step in the study of soil dynamics was the determination of the relationship existing between the dynamic properties and the design variables. Only preliminary studies of this nature have been carried out, but many important relationships have been manifested.

Dynamic Properties of Plastic Soils. One of the problems facing workers in soil dynamics is the application of their findings to various soils. It was thought that possibly some index of the soil properties could be found which would accurately indicate their value for any soil.

Many single-valued soil factors, such as percent of colloid, heat of wetting, moisture equivalent, capillarly pull, freezing-point depression, and others were investigated, but no satisfactory correlations were obtained. The Atterberg consistency constants, which are being used as an expression of soil consistency, were then studied. Since soil consistency is a term used to designate the manifestation of the physical forces of cohesion and adhesion acting within the soil at different moisture contents, and since these manifestations include the behavior of the soil towards pressure, thrust, and pull, and the tendency to adhere to foreign bodies, a distinct correlation between these constants and the physical forces involved in tillage should be expected. The results of the studies of the relationships existing between the Atterberg constants and the dynamic properties were so satisfactory that they have been presented in a special paper[9] and a brief review only will be included in this paper.

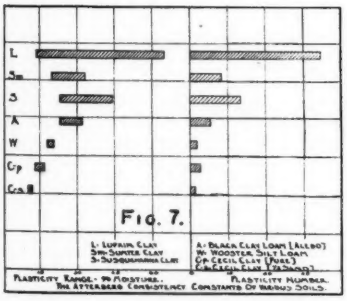
The consistency constants were determined according to the usual method as reported by Atterberg [10, 11] and Russel and Wehr[12]. The constants used are as follows: The lower plastic limit, that moisture content at which the soil can barely be rolled into a wire; the upper plastic limit, that moisture content at which the soil can barely

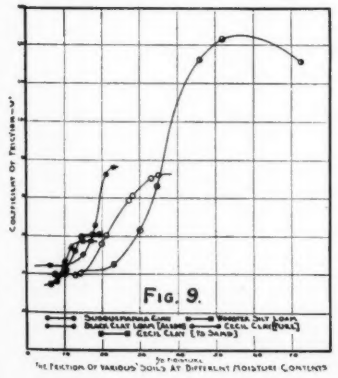
[9]Nichols, M. L., and Baver, L. D. An Interpretation of the Physical Properties of Soil Affecting Tillage and Implement Design by Means of the Atterberg Consistency Constants. (Presented for Publication to the International Soil Congress, Leningrad, Russia.) Jan. 1930.

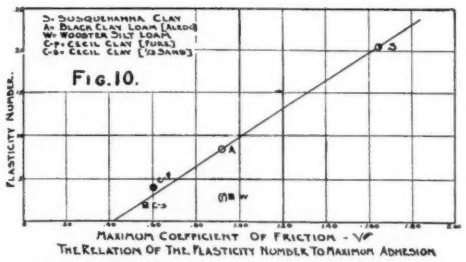
[10]Keen, B. A., and Blair, G. W. Plastometric Studies of Soil and Clay Pastes. Journal of Agricultural Science 19; 684-700, 1929.

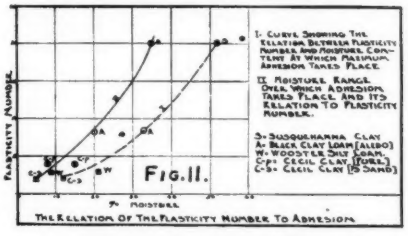
[11]Atterberg, A. The Plasticity of Clay, Int. Mitt Fur. Bodenkunde, 1:10-43, 1911.

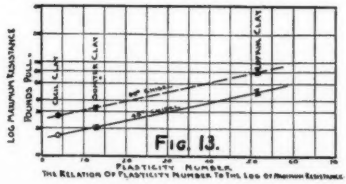
[12]Atterberg, A. The Consistency and Binding Power of the Soil. Int. Mitt. Fur Bodenkinde, 2:149-189, 1912.

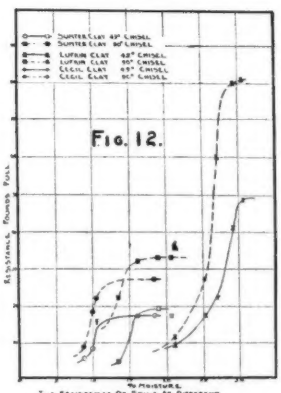


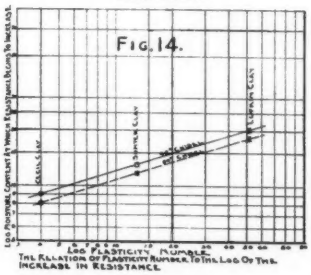



S: Susquehanna Clay
A: Black Clay Loam (Alleo)
W: Wooster Silt Loam
Cp: Cecil Clay (Pure)
Cs: Cecil Clay (75 Sand)
Fig. 10.
Plasticity Number.
Maximum Coefficient of Friction - V
The Relation of the Plasticity Number to Maximum Adhesion


I. Curve Showing the Relation Between Plasticity Number and Moisture Content at Which Maximum Adhesion Takes Place.
II. Moisture Range Over Which Adhesion Takes Place, and Its Relation to Plasticity Number.
S: Susquehanna Clay
A: Black Clay Loam (Alleo)
W: Wooster Silt Loam
Cp: Cecil Clay (Pure)
Cs: Cecil Clay (75 Sand)
Plasticity Number
Fig. 11.
% Moisture.
The Relation of the Plasticity Number to Adhesion







be made to flow under a certain force; and the plasticity number, the difference between the two plastic limits. The soil was moistened by the condensation of steam[4].

Description of Soils. A description of the soils used in this investigation is given in Table I. The values for the Atterberg constants are also shown in Fig.7. The colloid content was obtained by the ratio method, using water absorption as a basis. The SiO_2—sesquioxide ratio is that of the extracted colloid. It is not within the scope of this paper to discuss to any extent the effect of the composition of the colloid on the physical reactive properties of soil. The composition of the colloid affects the plasticity number and the place it occurs on the moisture scale. Since these factors indicate the value of the dynamic properties, as will be shown later, a brief review of the effect of chemical composition is given in Fig. 8. This chart is taken from data prepared by Baver[13], [14].

The friction curves of these soils are shown in Fig. 9. It will be noted from a comparison of the plasticity charts (Fig. 7) and the friction curves that maximum adhesion occurs at a moisture content fairly close to that of the upper plastic limit. That is, adhesion is at a maximum at that moisture content at which the soil barely flows under an applied force. Other relationships of the coefficient of friction to the Atterberg consistency constants are shown in Figs. 10 and 11. Fig. 10 indicates that maximum adhesion is proportional to the plasticity number. This should be expected since the plasticity number is a function of the per cent of clay. The curves in Fig. 11 show that there is a relationship between the plasticity number and the moisture range over which adhesion occurs, as well as between the plasticity number and that moisture content at which maximum adhesion takes place. The relationships between the coefficient of friction and the Atterberg consistency constants appear to be definite enough to safely calculate the friction curves of the soil for any particular metal from the Atterberg constants, after having established the relative adhesional values of the various metals.

TABLE I. Description of Soils Used in Alabama Investigation

Soil type	Location	Percent colloid	SiO_2 — $Al_2O_3+Fe_2O_3$	Upper plastic limit	Lower plastic limit	Plasticity number
Lufkin clay	Alabama black belt	80.0	3.80	64.77	13.20	51.57
Sumter clay	Alabama black belt			33.00	20.15	12.85
Susquehanna clay	Alabama coastal plain	55.0	2.46	44.17	23.85	20.23
Black clay loam (Aledo)	Illinois	37.0	2.91	32.00	23.89	8.20
Wooster silt loam	Ohio	25.0	2.25	20.63	18.06	2.57
Cecil clay (Pure)	Alabama Piedmont	23.0	1.30	17.00	13.00	4.00
Cecil clay (⅓ sand)	Alabama Piedmont	23.0	1.30	12.00	10.00	2.00

[13]Baver, L. D. The Relation of Exchangeable Cations to the Physical Properties of Soils. Journal of American Society of Agronomy, 20:921-941, 1929.

[14]Baver, L. D.
(a) The Relation of Organic Matter to Certain Physical Properties of Soils. (Accepted for Publication in Journal of American Society of Agronomy, 1930).
(b) The Atterberg Consistency Constants: I. Factors Affecting These Values. II. A New Conception of their Values.

In studies of the relation of compression to the Atterberg constants it was found that maximum compressibility occurs at approximately the same moisture range as that over which plasticity occurs. Therefore, the Atterberg consistency constants afford a means of calculating the range of compressibility of soils. The maximum compressibility of soils also appeared to be a logarithmic function of the plasticity number. Preliminary investigations seemed to indicate that similar relationships occurred between the consistency constants and shear.

If the dynamic properties of a soil are those which affect draft of implements, and if these have a definite relationship with the Atterberg constants, it would follow that with any given design of implement there would be a definite relationship between the draft and the Atterberg constants. For the purpose of determining if this was true, tests were made of the pull required to draw two chisels through each of three soils varying widely in plasticity number. The apparatus used consisted of two nickel-plated chisels, attached to a dynamometer[3], which were pulled through the soil at a constant depth and speed. The chisels were set at angles of 45 and 90 degrees to the surface of the soil. The relation of pull to moisture content is shown in Fig. 12. Studies were then made of the relations between the Atterberg consistency constants and pull. It was found that the maximum pull is a logarithmic function of the plasticity number, and that a double logarithmic relationship exists between the plasticity number and the moisture content at which the resistance to pull begins to increase. These relationships are shown in Figs. 13 and 14. These data show that the resistance offered by soils can be predicted from a knowledge of the Atterberg constants. This agrees with the report of Haines and Keen[15] that the drawbar pull is proportional to clay content, and the work of Keen and Blair[16], who found that the soils resistance to tillage implements is directly proportional to the force required to cause the soil paste to flow.

SUMMARY

The objectives of soil dynamics studies are briefly outlined and the variables considered are classified. The general value of the relationships of colloid content, particle size, and moisture content to resistance, compression, cohesion, adhesion, and coefficient of friction are shown by curves. Soil structure is discussed and the hypothesis is advanced that each soil has a "normal" structure which would afford a basis for quantitative studies of force reaction. The dynamic properties of plastic soils are shown to be indicated by the Atterberg plasticity constants with a sufficient degree of accuracy for safely predicting the soil's reaction to tillage forces from these constants.

[15]Haines, W. B., and Keen, B. A. Studies in Soil Cultivation: III. Measurements of the Rothamstead Classical Plots by Means of Dynamometer and Plough. Journal of Agricultural Science, 15:395-406, 1925.

[16]Russel, J. C., and Wehr, F. N. The Atterberg Consistency Constants. Journal of American Society of Agronomy 29 354-372, 1928.

New Hospital Barn Designed by Agricultural Engineer

A NEW hospital barn for the West Virginia University Experimental dairy farm has recently been completed. F. D. Cornel (Assoc. Mem. A.S.A.E), agricultural engineer of West Virginia University, designed the building. It will be used for research on contagious abortion, and other cattle diseases. It measures 26 by 50 feet, is of modern construction, and completely equipped.

Composite and Solid Steels for Farm Tillage Implements[1]

By R. H. McMillen[2] and F. F. McIntosh[3]

IT IS safe to assume that all those present are familiar with what is meant by soft-center steel and its performance in the field. They are also familiar with standard grades of solid plow and disk steels and their limitations. The men who are responsible for making these steels, probably lack the intimate knowledge of performance which is forced on the maker of agricultural tools. The maker of the steel does, however, have a first-hand knowledge of the fundamental characteristics of his products which has been forced on him through the problems of production and generations of experience in the exacting art and science of steel making. It is hoped that by presenting the steel man's point of view and experience, this paper will develop the point of view and experiences of the implement maker and the user of the implement to the mutal benefit of all. For sake of classification the tillage steels will be divided into the two groups of composite or soft-center steels, and the solid steels.

Composite or Soft-Center Steels. A composite steel of any kind is always a product which has been developed to obtain in a single piece of metal two widely varying characteristics. In the case of the soft-center steel, which represents an effort to combine the maximum obtainable hardness with the greatest amount of toughness, these characteristics can be obtained by a composite structure composed of high carbon steel on the outside surface with low carbon center to give toughness and ability to withstand shock. The hardness of the outer high carbon portion of the structure can not be developed without heat treatment. The full measure of toughness of the central portion of the structure, that is, the low carbon core, also requires a heat treatment to develop its full toughness and strength. Unfortunately the two grades of steel require different temperatures for the development of their desirable characteristics. The soft-center core of the structure requires a high temperature for refinement of its grain and the development of maximum toughness and strength. The high carbon surface portion of the structure should have a much lower temperature to develop strength with full hardness. The treatment of this outer layer from a high temperature gives a coarse grain which lacks strength and is highly undesirable. This dilemma can be met either by giving the finished component a double treatment or first a high temperature to refine the core, followed by a low temperature to refine the surface, or, by resorting to a compromise treatment, which like all compromises is a serious departure from the ideal. To illustrate this problem the following specific description of the composition, structure, hardness and toughness of the different components of the soft-center steel is necessary.

Soft-center steel is manufactured from a composite ingot which is made by casting high carbon steel around a soft steel insert plate. The insert plate of soft steel is made to a specification of carbon not more than 0.12 per cent. This is a special grade of soft steel selected to give good welding properties and ductility. The preparing of this insert plate, placing it in the mold, casting the hard steel around it, and the working of the composite ingot through successive stages of reheating down to the finished plate, which is sheared into shapes ready for shipment to the manufacturer of agricultural implements, is a long series of operations taxing to the utmost the skill and knowledge of the steel maker. It is a specialty operation in which years of experience have developed the technique necessary for successful production of a high-grade product.

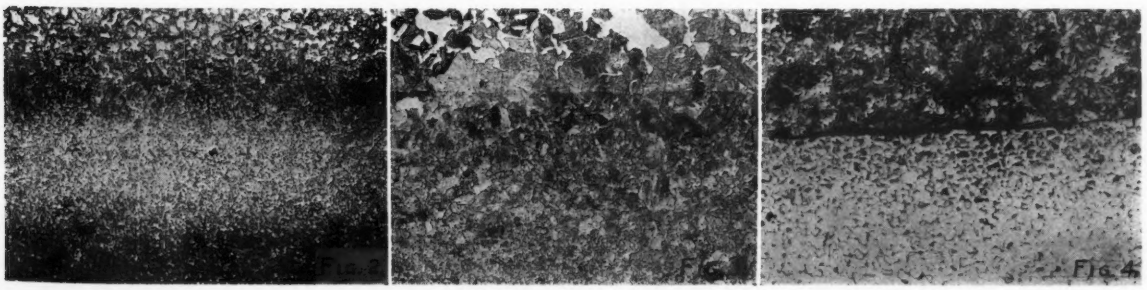
Micrograph No. 1 (Fig. 1) at a magnification of 22 shows a section of the finished soft-center plate. The outer portion or hard shell of this plate is composed of a steel containing from 0.85 to 1.40 per cent carbon, depending upon the service required. When hardened this outer shell is file hard. In this condition of maximum hardness the steel is strong but brittle when hardened from a temperature, which is sufficiently high to fully harden the steel but not high enough to coarsen the grain. If the temperature were sufficiently high to coarsen the grain, the hard steel would be weak as well as brittle. In either condition it would be easily broken by impact or suddenly applied stresses were it not reinforced by the low carbon center plate. The soft center is tough in spite of the fact that it has had the same hardening operation as the high carbon shell. If a piece of the core could be removed from the finished structure it would bend flat on itself without breaking.

The combination of the desired qualities of hardness, strength, and toughness in the finished structure depend primarily on the character of the weld between the low carbon core and the high carbon shell. Micrograph No. 2 (Fig. 2) at 100 magnifications shows a satisfactory weld on a sample of properly hardened soft-center steel. The light colored band following the central long axis of the micrograph represents the weld. The dark side of the micrograph is the hard high-carbon shell. The white constituent at the other edge of the micrograph is the ferrite of the soft insert. This micrograph represents about the maximum diffusion of carbon to be found at a weld. There has been, in this instance, a slight loss of carbon for 0.0075 inches of the high carbon shell. The insert plate

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929.

[2]Metallurgist, Crucible Steel Company of America.

[3]Metallurgist, Crucible Steel Company of America



has absorbed carbon for about 0.01 inches. This diffusion of carbon has no noticeable effect on either component of the composite structure. It does indicate an excellent weld. This particular example could be classed as a perfect weld.

Micrograph No. 3 (Fig. 3) at X100 shows the same material in the annealed condition. This is an example of a perfect weld where there has not been as much diffusion of carbon as in No. 2 (Fig. 2). The annealed condition of this sample makes more obvious the relationship between the two grades of steel at the weld. In this particular sample the high carbon steel has lost carbon for a distance of about 0.005 inches from the weld. The insert plate has absorbed carbon for a depth of less than 0.005 inches.

Number 4 (Fig. 4) at the same magnification shows an imperfect weld. This micrograph was taken on the steel in the natural condition. It is desired to direct attention to the fact that there is very little diffusion of carbon from the high carbon shell to the low carbon insert. This fact is clearly shown by No. 3 (Fig. 3) on the annealed sample. Troubles with soft-center steels which have been attributed to carbon diffusion, are cases of improper diagnosis. Diffusion is slight and has no harmful effect on the finished structure. It can be considered as an index of the perfection of the weld. The greater the carbon diffusion the better the weld, although good welds are observed which show no diffusion of carbon. The exact nature of a perfect weld is not known. It can be seen from Micrographs No. 2 (Fig 2) and No. 3 (Fig. 3) that a good weld represents a very intimate contact between the two metals. No. 4 (Fig. 4) at X100, illustrating an imperfect weld, shows an absence of this intimate contact. In many instances a poor weld shows that there is an inclusion between the two metals at the point of contact as is seen in this photograph. The operations involved in reducing the ingot down to the finished soft-center plate are of such a vigorous and drastic nature that imperfections of weld are discovered before the material passes final inspection at the steel maker's plant.

Mention has been made of the dilemma in heat-treating soft-center steel due to the fact that a high temperature—above 1600 degrees (Fahrenheit)—is necessary to refine the grain on the soft center and thus secure the maximum toughness, and that a comparatively low hardening temperature (about 1425 degrees) gives the best results on the high carbon shell. This is a situation which is commonplace and well understood by the metallurgist. It is a situation which he regularly meets with case-hardened articles. His solution is simple and sound. The metallurgist says first heat to 1650 degrees, or higher; then cool in oil or air; then, as soon as the steel is cooled to black and white still warm (1000 to 700 degrees), reheat to 1425 degrees and cool in iced brine. The result is a composite structure with fully hardened fine-grained shell and a tough fine-grained core. The metallurgist says "Fine," but the production manager says "Impossible." The result is that the metallurgist must do the best he can under the limitations imposed by commercial considerations.

Micrograph No. 5 (Fig. 5) at X2 magnification is an attempt to reproduce photographically the ideal fractures which can be obtained by a double treatment. The photographic reproduction of fractures is always unsatisfactory. Visual examination of the fresh fracture shows both core and case to be fine grained. The case is file hard and the core is in condition of maximum toughness for the grade of steel used.

Micrograph No. 6 (Fig. 6) at X2 magnifications shows the fracture of material which has been given good commercial single-treatment practice. Visual examination of this fracture shows a lack of strength and toughness displayed in the fracture of the double-treated material. This difference is so apparent that it can readily be seen in the micrograph. No. 7 (Fig. 7) at the same magnification

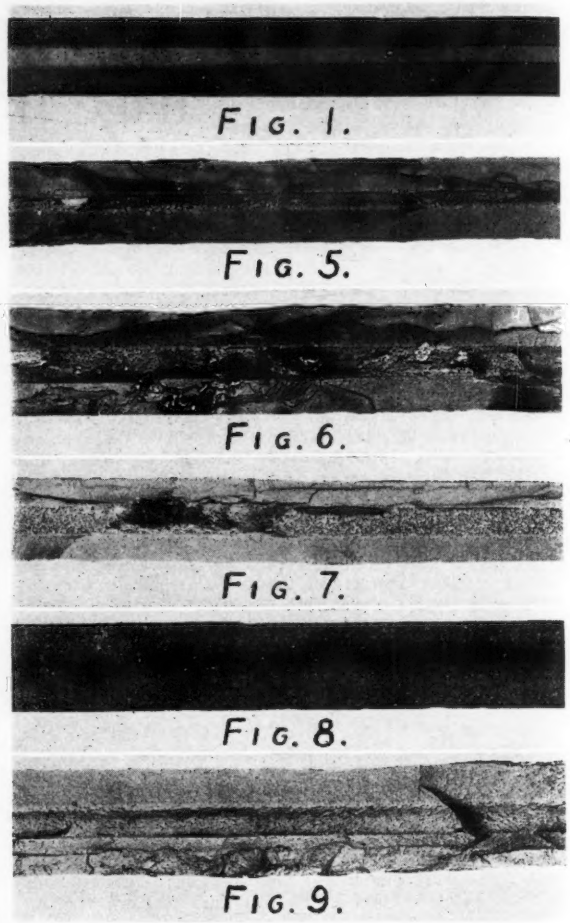


FIG. 1.

FIG. 5.

FIG. 6.

FIG. 7.

FIG. 8.

FIG. 9.

represents a condition obtained at times under commercial production when single-treatment practice is not good. The coarse-grained brittle condition of this sample is quite apparent even in the micrograph. By carrying mal-treatment to extremes sometimes observed in manufacturers' plants, the soft center can be changed to a metal which has very little resistance to sudden impact. When the core loses resistance to impact and toughness the composite structure loses much of its merit. Micrograph No. 8 (Fig. 8) at 2X shows the coarse grain which is obtained on the high carbon shell when the temperature is carried up to the range which will refine the core. The shell lacks strength and is extremely brittle in this coarse grain condition. So much has been said and written these days in regard to alloy steels that the steel maker naturaly expects the query as to why an alloy steel cannot be used which will have all of the desirable characteristics of hardness, toughness and workability which are obtained in the composite steel. You can be assured that the steel maker was the very first to search for the magic alloy which would fulfill this specification and dispense with the necessity of producing a composite steel. Those who are not actually engaged in steel manufacture cannot realize the number of difficulties which are involved and the losses incurred in the production of a satisfactory soft center steel. The steel maker has not been able to develop a satisfactory alloy steel to replace the soft-center product. It is believed that a big forward stride has been taken, however, by the development of a soft center which avoids the dilemma in heat-treatment presented by a composite structure, such as

ordinary soft-center steel composed of two metals requiring widely different temperatures for their treatment to develop the hardness and strength of the one element and the toughness of the other. A soft-center steel has been developed under the direction of one of the authors (R. H. McMillen) at LaBelle Works of Crucible Steel Company of America, in which the heat-treatment necessary to develop maximum toughness, strength, and refinement in the soft center coupled with full hardness in the hard outer case is obtained at one and the same temperature, giving a soft-center product in which both the outer high carbon shell and the central soft-center core show the maximum of refinement, strength, toughness and hardness all obtained from a single treatment with characteristics of weld equal, if not superior to, the weld obtained in the standard soft-center steel. Laboratory and service tests on this new composite product have warranted the application for a patent.

This special soft-center steel is a composite steel with the outer shell of high carbon steel showing, when fully hardened, a hardness of 65 to 68 Bockwell C (Brinell 654 to 712). The insert plate is a low carbon alloy steel containing sufficient manganese to lower the critical point of the soft-center member of the structure to the point where it is possible to refine the insert without raising the temperature to the point where the high carbon shell will be weakened and given a coarse grain due to hardening from too high a temperature. This means that it is possible in a single hardening operation to secure full hardness of the high carbon portion of the structure, and refinement and toughening of the insert member at the same temperature. The steel maker has always felt that it was impossible to use anything in the nature of an alloy steel for an insert in soft center, on account of the difficulty of securing a good weld between an insert of alloy steel and the high carbon steel. The high manganese low carbon insert used in this new grade of soft-center steel is an alloy steel with all of the qualities and properties necessary for an ideal insert. The production on a commercial scale of soft center with this low carbon high manganese insert has demonstrated that a satisfactory weld can be obtained. The manganese content of the soft center increases its strength without reducing its toughness. The result is a composite structure which is file hard on the surface. The surface layers have not been coarsened in structure with resulting loss in strength. The core is fully refined and is tougher and stronger than a regular carbon insert plate.

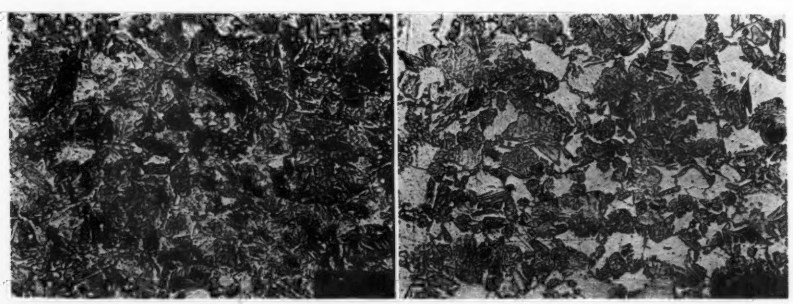
Micrograph No. 9 (Fig. 9) illustrates the fracture obtained on this new grade of soft-center steel when hardened from a temperature of 1475 degrees, and quenched in brine in the usual way. This fracture shows a good grain on the high carbon portion which is fully hardened and an extremely tough fracture with fine grain in the center plate. These characteristics are not well shown photographically. To appreciate the merits of this soft-center steel one must take samples of the material and observe the way they resist fracture and the desirable characteristics as shown by visual examination of the fracture. Micrograph No. 10 (Fig. 10) at X300 shows the structure of the special manganese steel insert after treatment. Micrograph No. 11 (Fig. 11) at X300 shows the structure of the regular low carbon steel insert after a standard heat treatment. The manganese insert of the special soft center will show more than 50 per cent greater tensile strength than the low carbon soft center coupled with greater toughness. The high carbon shell of the special product has greater strength due to the fact that standard hardening practice on regular soft center gives a comparatively coarse grain with corresponding loss of desirable physical properties.

Solid Steels. The solid steels for tillage implements naturally fall into two classes, namely, solid steels for shares, moldboards, etc., and solid steels for disks. The first class, that is, the solid steels for shares and moldboards, are used where service demands are not exacting. Time will not be taken, therefore, to discuss this class in detail. It consists of steels with carbons ranging from 0.30 to 0.90 per cent, the analysis of steel applied depending in each instance upon the condition of fabrication in the factory making the finished article, and the conditions of service to be met. This class of steels is generally put into service by the implement maker in the natural condition. There are cases in which the manufacturer resorts to some special hardening operation to secure an improved product. These hardening operations are usually an integral part of the manufacturing operation rather than a special heat-treating operation.

Solid steels for disks rank in importance with soft center as tillage steels. As disks are not composite structures it has been necessary to select for this service the hardest steel which would resist the impacts and sudden stresses met with in the field. To meet this demand it was necessary to sacrifice some of the hardness and ability to hold a cutting edge obtained with the fully hardened composite steel.

The application of disks to tillage implements was developed on disks which were supplied to the trade in natural condition. By natural condition the steel maker means that the structure and physical properties of the steel are those resulting from his last fabricating operation. The steel in the natural condition has not had any treatment or processing intended solely to alter the physical condition of the steel. In order to secure a good natural disk the steel maker was forced to exercise great care in all of his processing operations. Small variation in operating conditions gave wide variations in physical characteristics of the finished product. In spite of the fact that the disks were finished cold to secure good physical characteristics, there was always a noticeable lack of uniformity in the physical properties. For use in the natural condition disk steel containing about 0.80 per cent carbon and about the same amount of manganese is used.

All metallurgists know that some form of heat-treatment is necessary to develop fully the desirable characteristics of a steel. It is often necessary, however, to spend time and effort to convince the user of the steel that he will profit by paying more money for the heat-treated article. The heat-treated disk has passed through the missionary stages. There has been sufficient recognition of its merits by progressives to place it in commercial production. Its general recognition and adoption has been rapid.



The heat-treated disk is of about the same composition as the untreated disk, the analysis being of the proper balance to develop the physical characteristics desired. It has been carefully heated to the proper temperature for full hardening in a specially constructed furnace with automatic temperature control. It has been quenched in oil in special machines with quenching jigs which hold the

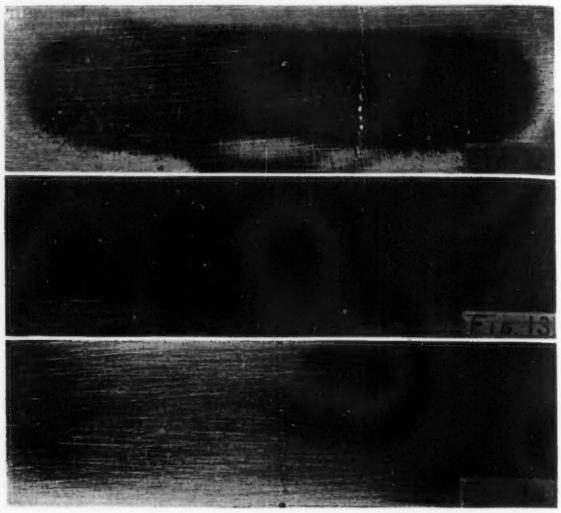
disk true to shape and prevent warpings. As a final operation it has been tempered in another special furnace under automatic control. The result is a uniform product which will show hardness of about 44 Rockwell C (Brinell 364) and a toughness and strength never approached by an untreated disk.

If a collection of untreated disks were made from various sources and tested in comparison with heat-treated disks, the relative merits of the two would be apparent to all. Throw the disks edge down on a concrete floor; many of the untreated disks would break, chip or bend, but none of the heat-treated disks would be broken or marred. Strike the edge ten blows with a two-pound hand hammer; the edges of the former would chip, break and bend, but of the latter no breakage and very little marring of the edge would occur. Place disks on a concrete floor convex face up and strike 200 blows with a sixteen-pound sledge; all the untreated disks would break or bend with comparatively few blows, but none of the heat treated disks would be broken or injured in any way. Place two disks together with their cutting edges in contact and pass a bolt through the center holes. Screw nut down until the disk is deflected the full amount of its concavity, and the two concave faces are touching each other at the center. With the heat-treated disk this test can be made, and when he bolt is released the disk will resume its former shape without showing a set. The natural or untreated disk will break or take a permanent set long before the two concave faces have been brought into contact.

Back of the performance of all steel articles lies the governing factor of quality. The analysis of a steel gives the general properties which may be expected. Proper treatment of the steel will develop these properties and improper treatment will more or less destroy them, and improper treatment may to an extent not generally realized render the finished article totally unfit for service. With composition of the steel correct, and treatment perfect, a difference in performance under service conditions is observed which may amount to complete failure where quality is poor and phenomenal performance where quality is excellent. The steel problem which faces most engineers in the farm machinery industry is to secure the best composition for each particular application, give the steel proper handling and treatment, and have a metal of high quality factor to assure consistent satisfactory performance. Of these three requirements for satisfactory results, two can easily be specified, defined, observed and tested. The composition and the treatment of the steel are simple engineering and operating problems. The third requirement, however, described as quality, is little understood or appreciated and difficult to define.

To those unskilled in agriculture there is little difference in soils. To the average metallurgist there are different kinds of steel according to their method of manufacture, as, for example, Bessemer, basic open hearth, acid open hearth, electric and crucible. To each method of manufacture he is given to assigning a certain degree of merit. If it should happen that the metallurgist has not specialized in steel making with particular reference to quality, his assignment of degree of merit according to process of manufacture would probably fail to be fully confirmed by searching service tests. To the metallurgist who has spent years of specialized study of the problems involved in quality steel making, the variations in quality of steel are of a magnitude appreciated by no one else. By control of steel-making conditions two pieces of steel of identical composition and given identical treatment, made in the same furnace, but under different operating conditions, can be made to differ in physical characteristics to the same degree that a piece of hickory will differ from a piece of hemlock.

As a crude and easily understood illustration of differences in quality, three samples of tool steel have been hardened and etched to show depth of hardness. These three samples represent three steels of practically the same composition. The heat-treatment of the three samples has been identical. Two of the steels were melted in one type of furnace, one was melted in quite a different type of furnace and under faulty melting practice. The only difference between the three lies in the melting practice used. The samples are from bars ⅝ by 2 inches. Sample No. 12 (Fig. 12) at 2½ magnification shows a variable depth of hardness with a soft spot on one side reaching to the surface. The depth of hardening at the deepest section on the side is less than 0.10 inches. Sample No. 13 (Fig. 13) at the same magnification shows an even hardening to a minimum depth on the side of about 0.16 inches. Sample No. 14 (Fig. 14) has hardened through the full section of ⅝ by 2 inches. It is not intended to convey the idea that this example was selected to illustrate the difference between good and bad quality steels. It illustrates the difference between the two steels of high quality—Nos. 13 and 14 (Figs. 13 and 14)—and one steel of poor quality—No. 12 (Fig. 12). The practice used in making the steel represented by samples showing complete hardening (No. 14) and the sample showing even depth of hardness (No. 13) was good in both cases and the quality of both steels is good. In applying steel for service, however, one steel is the proper quality for one application. The other steel is the proper quality for best results on another application. The point with these two steels (Nos. 13 and 14) is that they are both good quality but that one might fail where the other would succeed and the quality steel maker must not only make good steel, he must make good steel which will fit the job. The sample (No. 12) showing irregular hardening and soft spots which almost reaches the surface, illustrates a steel of poor quality. This poor quality steel would show just as hard on the surface as the other two steels. An unfortunate feature of this whole situation is that in addition to experience, knowledge, and the utmost care in every detail of processing, high quality steel cannot be made cheaply. In general with steel, as with all other things, the purchaser gets what he pays for. It is difficult for a purchasing agent or even an engineer to see how two steels may vary in merit when they are both of the same composition and show, for example, the same hardness after quenching. If the quality steel maker would be granted one wish, and one only, this wisest choice should be that the book of knowledge be opened to all at the chapter telling the full truth and significance of quality in steel.



Influence of Head on the Movement of Water in Gila Clay and Gila Clay Loam

By C. W. Botkin[1]

IT IS well known that water moves slowly in clay soil and that the movement is almost imperceptible if the fine-textured soil contains alkali. As a result the reclamation of heavy alkalied soils is extremely slow and very difficult. Any practical means of materially increasing the rate of percolation in these soils deserves consideration and may prove of economic importance in the reclamation and preservation of large areas of heavy soil. The question has frequently been raised as to the advisability of increasing the depth or head of irrigation water. This question is of interest not only in the reclamation of soil but also in the conservation of water. No data with a direct bearing on the subject could be found; consequently, it appeared desirable to study the influence of head of water on the rates of penetration and percolation in these fine-textured soils.

Previous Knowlege. Experiments have proved that the capillary forces in clay are very great, pressures equivalent to 26.8 feet of water[2] having been demonstrated; and that the upward movement of water in clay is very slow and does not attain heights above 6 feet [3, 4, 5]. In view of the small effect of a force of this magnitude, one would not expect the head of water to have much influence in heavy soils. However, it does not appear reasonable to assume that irrigation water would never penetrate below 6 feet in clay soil, and that the influence of head is entirely negligible.

Shaw and Winterer[6], working with rather coarse-textured soils, have shown that the percolation rate in gravelly sandy loam decreases quite rapidly for the first ten days, when under a constant head; and that the hydraulic gradient in fine sand is not represented by a straight line, but by a curve, which indicates increase in friction with increase in depth. These authors also state that increased head results in increased percolation.

In a study of the effect of the constituents of alkali, fertilizers, and soil amendments on the movement of water in Gila clay and Gila clay loam[7] at the New Mexico Agricultural Experiment Station, it was observed that permeability diminished with depth; and that the decrease was greater, proportionally, than the increase in depth. This was most pronounced in deflocculated soils, and was attributed to the swelling of colloidal matter and to compacting by the weight of the overlying soil and water. The columns of soil were short (one foot) and the head of water did not exceed 6 inches; consequently, the compacting by weight was probably a factor of minor importance.

The slow rate in fine-textured soils is evidently the result of an enormous resistance. Resistance in such materials is said to increase with the surface area of the particles. Since these soils contain a high percentage of colloidal matter, the resistance is undoubtedly related to the large surface area of the colloids. Compacting would increase the concentration of surface; and colloidal swelling, especially under pressure, would also function to diminish permeability. Consequently, the effect of the head of water may be quite different in fine-textured soils than in sands and coarser materials.

Experimental Work. In order to obtain information on this subject a study was made of the influence of different heads of water on the rate of penetration into the air-dried soils and on the rate of percolation after wetting. The experiments were conducted with one-foot depths of the pulverized, air-dried soils because it was thought that the influence of the head of water would be an optimum under these conditions. The tests were made with Gila clay and Gila clay loam, and with these soils flocculated by aluminum sulphate and deflocculated by sodium carbonate.

The soils were air dried and pulverized sufficiently to pass through a one-millimeter screen. The results of a mechanical and a chemical analysis of these soils have been published elsewhere[8]. The sample of loam contained 0.21 per cent of soluble mineral matter and was more deflocculated than the clay which contained 0.11 per cent. The mixtures with aluminum sulphate (crystals, 0.25 per cent, water-free basis) and sodium carbonate (0.25 per cent, anhydrous) were made by thoroughly mixing the powdered chemical with the air-dried soils.

The experiments were conducted in two-inch percolation tubes of Pyrex glass supported in vertical position. The tubes were 15 to 74 inches in length; and were closed at the bottom with a rubber stopper, through which passed a one-half-inch drainage tube. The top of the drainage tube was screened with a fold of cheesecloth. The soil to a depth of one foot was placed in the lower end of the tube and sufficient water added to bring the level to the desired height. The water was kept at this level by a siphon connected with a two-liter beaker containing water automatically supplied at the same level from an inverted three-liter flask. By this method the levels in the percolation tubes did not vary more than one-eighth inch. Filtered Rio Grande water was used. The percolates were received and measured at regular intervals in graduated cylinders. The apparatus was supported by a wooden rack secured to a wall of the building. Fixed lines were made on the percolation tubes, indicating the one-foot level (top of soil column). The penetration was measured downward from this line at regular intervals of time. The swelling, when appreciable, was measured upward from this line. The experiments were conducted simultaneously on each different soil or soil mixture in order to avoid variations resulting from differences in temperature.

Preliminary experiments were conducted to determine the effect of the mechanical process of compacting the soil in the tubes on the movement of water through the soil. It was found that this is a very important factor and that it may cause serious experimental error. In order to eliminate this source of error, as much as possible, and to show the effect of head under different amounts of compacting, two percolation tests were conducted simultaneously with each head. In one the soil or soil-mixture was packed as loosely as possible; and in the other the soil or soil-mixture was packed rather tightly by a jarring and shaking process. Each process was carried out as uniformly as possible on all samples. The results obtained by these methods of compacting are designated in the figures

---

[1]Professor of chemistry, New Mexico A. & M. College.

[2]Lynde, C. J., and Dupre, H. A., 1913. A new method of measuring the capillary lift in soils. J. Am. Soc. Agr., 5, p. 107.

[3]Hilgard, E. W. 1905. Soils, p. 203. The MacMillan Company.

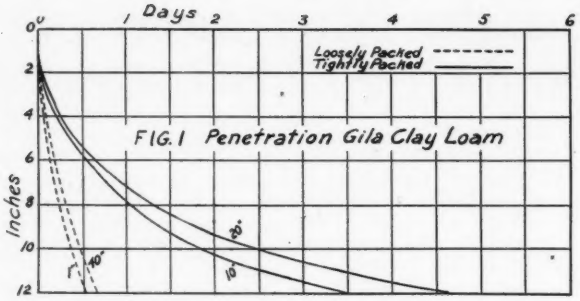
[4]Willard,, R. E., and Humbert, E. P., 1913. Soil Moisture. Bul. 86, N. M. Agr. Expt. Sta., p. 26.

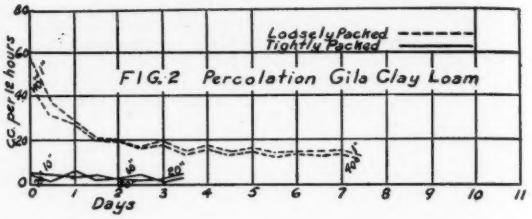
[5]Mosier, J. G., and Gustavson, A. F., 1917. Soil Physics and Management, p. 207. J. B. Lippincott Company.

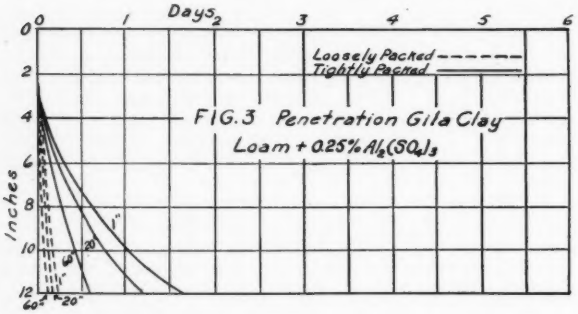
[6]Shaw, C. F., and Winterer, E. V., Percolation of water through soils. Rept. Col. of Agr. and Agr. Expt. Sta., Univ. of Cal. 1922-1923, p. 234.

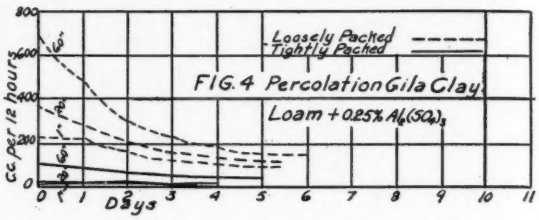
[7]Botkin, C. W., 1927. The effect of the constituents of alkali, fertilizers, and soil amendments on the permeability of certain fine-textured soils under irrigation. N. M. Agr. Expt. Sta., Bul. 160.

[8]Bul. 160, N. M. Agr. Expt. Sta., p. 15. The Gila clay loam is the "Poor Soil" No. 1; the Gila clay the "Poor Soil" No. 4.









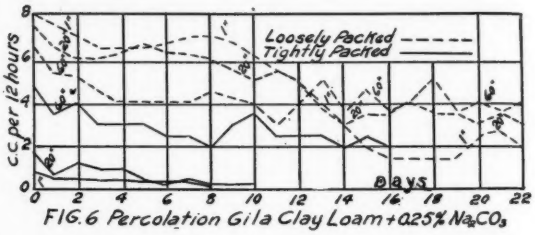
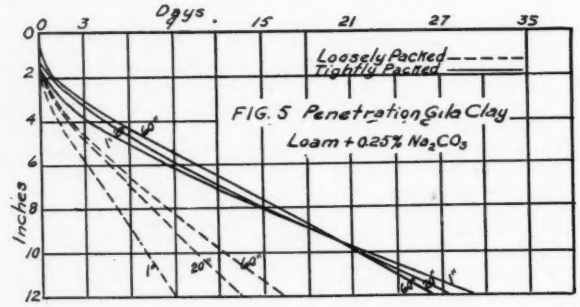
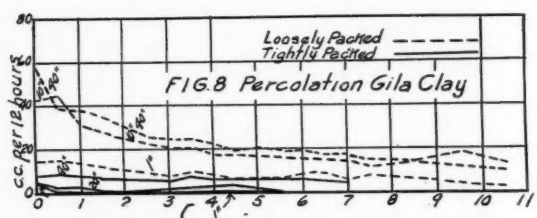
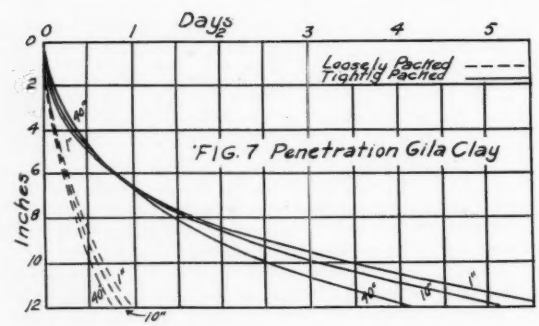
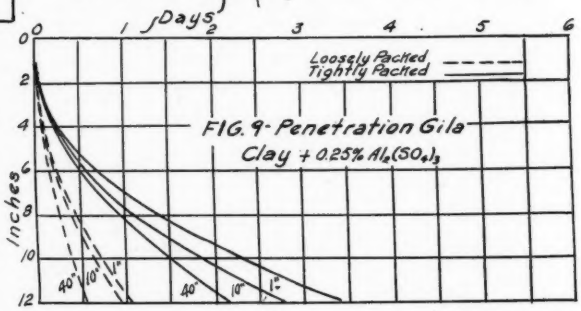


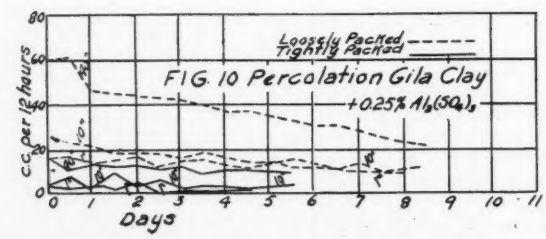
FIG. 6 Percolation Gila Clay Loam + 0.25% Na_2CO_3

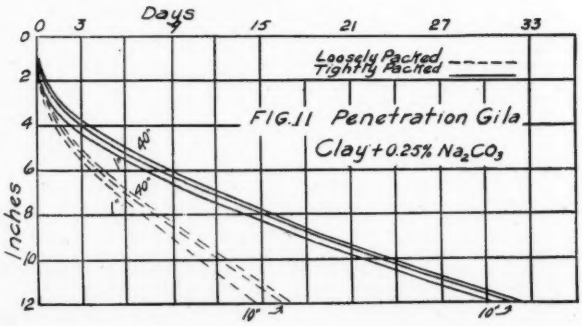












as from "loosely" or "tightly" packed soil columns. The experiments on the Gila clay loam by each method were made in duplicate. There is little difference between the values obtained from the duplicate tubes with the higher heads of water, but considerable difference for the lower heads. This difference, however, is not sufficient to cause doubt as to the approximate correctness of the values given in the figures. The average values have been plotted for the tests made in duplicate.

Experiments were conducted with the Gila clay loam, loosely packed, under heads of 1 inch and 40 inches; and tightly packed with heads of 10 and 20 inches. The penetration data are plotted in Fig. 1 and the percolation data in Fig. 2. Tests were made on the same soil containing 0.25 per cent of aluminum sulphate, and also containing 0.25 per cent of sodium carbonate; the heads of water in each case being 1, 20, and 60 inches for both the loosely and tightly packed mixtures. The data obtained with the aluminum sulphate mixtures are plotted in Figs. 3 and 4, and those obtained with the sodium carbonate mixtures in Figs. 5 and 6.

Similar penetration and percolation experiments were made with the Gila clay. The heads were 1, 10, and 40 inches for both the loosely and the tightly packed columns of the soil and also for the mixtures of this soil with aluminum sulphate and with sodium carbonate. The data are shown graphically in Figs. 7 to 11.

Results. The relative positions of both the penetration and the percolation curves in Figs. 1 to 11 show that the head of water, up to 60 inches, does not greatly influence the rate of water movement in these fine-textured soils, and that the head of water is not a very important factor in comparison with the effects of packing or with the influence of flocculants or deflocculants. This factor, however, is measurable. It is most evident in the soils flocculated with aluminum sulphate and is least perceptible in the tightly-packed deflocculated soils.

In the flocculated soils (Figs. 3, 4, and 7 to 10) higher heads of water increased the rates of penetration and percolation; and in the deflocculated soils (Figs. 1, 2, 5, 6, and 11), for a time at least, the higher heads decreased the rate of water movement. This decrease was most pronounced in the loosely packed clay loam deflocculated with sodium carbonate (Fig. 5). From the relative position of the curves for the different heads it appears that these effects are only roughly proportional to the head. The measurements, however, may be somewhat in error because of slight differences in compacting.

These influences on the rate of penetration resulting from differences in head appear to increase with time and depth, with the possible exception of the tightly packed, deflocculated mixtures (Figs. 5 and 11). The depth used in the experiments, however, is not sufficient for conclusions on this point. The rates of movement in the tightly packed loam-sodium carbonate mixtures change and become more rapid for the higher heads after about 20 days (Fig. 5). Similar alterations occur in the loosely packed mixtures after about 25 days (Fig. 6). The cause and significance of these alterations in the deflocculated loam have not been determined. The proximity of the penetration curves for the tightly packed sodium carbonate mixtures with either the loam (Fig. 5) or the clay (Fig. 11) show that the head has a minimum influence under such conditions.

The apparent decrease in rate with time and depth, which is indicated by all the curves in some degree, is believed to be caused by colloidal swelling. The tightly packed deflocculated mixtures exhibit the greatest increases in volume on percolation and also produce the greatest retardation of water movement. The moisture penetrating into the dry soil of these tubes is not sufficient to saturate the soil, and, after it has reached the bottom of the column, several days are required before there is sufficient water to drain from the soil. This suggests that the tightest and most resistant portion of the soil is near the top, where the swelling has reached a maximum. The penetration curves are similar to curves representing colloidal swelling. If these curves (Figs. -1, 3, 5, 7, 9, 11) are considered as representing the swelling of the soil colloids, with the swelling on the horizontal lines to the right and the time on the vertical lines downward, no grave discrepancies are encountered. The curves then indicate that the deflocculated colloids swell much more rapidly and result in a much larger amount of swelling than the flocculated colloids. There is about 10 per cent more soil in the tightly packed columns; consequently, the swelling here should exceed that in the loosely packed columns by this percentage. The curves, considered as swelling curves, indicate a larger difference. This is probably because more of the swelling in the loosely packed soils, especially at first, is accommodated in the larger volume of pore space occurring in these soils, and consequently the swelling is not so effective in retarding water movement. With the exception of the lower heads on the sodium carbonate mixtures, practically no increase in volume was observed in the loosely packed columns of soil after percolation. In the deflocculated soils it is probable that the swelling is more effective in resisting the movement of water under the higher heads, because the pressure of the head may decrease the pore space as a result of a greater fluidity in the deflocculated colloids.

From the percolation curves (Figs. 2, 4, 6, 8, and 10) it is evident that the percolation rates with the different heads and methods of compacting are similar to and in harmony with the penetration rates; and that there are no pronounced changes in the rate of water movement after the soils have become wet. This indicates that the forces concerned with the wetting of the soil and with the displacement of adsorbed air are not controlling factors; and it supplies further evidence that the rate of movement depends on a resistance which develops after the soil is wet. This resistance is intimately associated with the degrees of compacting and of flocculation. The continued decrease in the rate of percolation shown by practically all the percolation curves cannot be attributed directly to the original degree of compacting nor to the compacting effect of the head of water, but must result from the continued swelling of the colloids.

The greatest increases in soil volume on percolation occurred in the tightly packed, deflocculated soils under the lower heads of water. The swelling was slight in the loosely packed soils and none was observed in the loosely packed, flocculated soils. The maximum swelling under the one-inch heads in the deflocculated soils was 0.7 inch (about 6 per cent). Since the errors in measurement are rather large, these data are not given. However, the results mentioned above may be accepted as qualitative.

Mention has already been made of the large difference between the rates of water movement in the loosely and in the tightly packed soils. This difference is a demonstration of one of the values of cultivation. The uncompacted condition provides more room for the swelling of the colloids without serious interference with percolation. The tightly packed soils of the experiment were not nearly so dense as these fine-textured soils become in the uncultivated fields. Here natural conditions favor a maximum of compactness. When such soils are deflocculated by alkali, the colloidal swelling which occurs on wetting probably accounts for much of their imperviousness. Consequently, under such conditions no appreciable improvement in percolation can be hoped for from a large increase in the head of water.

The importance of the state of flocculation as a factor influencing water movement in fine-textured soils is emphasized by the data in the figures. This factor also deserves mention because it has a rather direct bearing on the subject of this paper. The difference in the effect

of head on penetration in the Gila clay and Gila clay loam is attributed to a greater degree of deflocculation in the loam. When flocculated the loam containing a lower percentage of colloids takes water much faster than the clay (Fig. 9). When deflocculated the movement is also slower in the clay (Fig. 11), and for a time it is somewhat faster for both soils under the lower heads. These differences between the clay and the loam would be expected, because of the higher percentage of fine-textured material in the clay. However, the differences between the rates of water movement in these two soils, whether in the natural condition or containing aluminum sulphate or sodium carbonate, are not nearly so large as the differences resulting from the admixture of these chemicals.

Some of the curves, particularly the percolation curves for the loosely packed soils in Fig. 2 in which the points plotted indicate day and night quantities of percolate, show maximum movements for daytime. This at first was thought to be the result of higher temperatures during the day. The temperature curves for the period, however, show considerable variations from day to day that are not associated with variations in the percolation curves, and suggest the possibility that light may have an influence in increasing percolation.

SUMMARY

The head of water does not greatly influence the rate of water movement in Gila clay and Gila clay loam and is of little consequence compared with the effect of compacting or of flocculation. This influence, however, is measurable.

Higher heads cause small increases in both penetration and percolation in the flocculated soils. In the deflocculated soils the higher heads, for a time, cause small decreases in the rate of water movement.

No marked change occurs in the rate of water movement when the dry soil becomes completely wetted.

These phenomena appear to result from the swelling of the soil colloids, which is greater for the deflocculated soils and more effective in retarding water movement when the soils are more compact.

A large increase in the head of irrigation water does not appear to give any practical assistance in the removal of alkali from heavy compact soils, and may hinder the process slightly if the heavy soils are very loose.

Electric Hay Hoists[1]

By E. W. Pilgrim[2]

TO DETERMINE the size of motor for a hay hoist, we should know (1) the weight of a fork full of hay (2) the hoisting speed (3) the efficiency of hoist.

The weight of a fork full of hay will vary depending on the kind of hay and how dry it is; but since the hoisting time is about 30 seconds or less, the overload capacity of the electric motor will be sufficient for the heavier ones, for calculations an average weight can be used.

A load of hay will weigh from 2000 to 3000 pounds. The average is probably 2500 pounds and would be unloaded in five 600-pound pulls, allowing for the weight of the fork and pulley block and a short length of rope.

During the past summer, I have checked the hoisting speed on several hay hoists. The data is shown in the table.

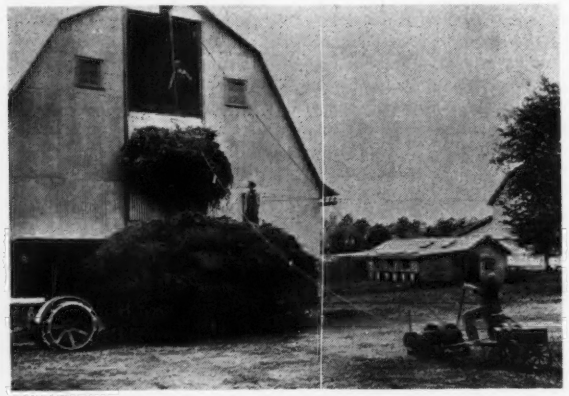
From this table you will note that there is a wide range of hoisting speeds. To insure a minimum shock to the equipment when changing from hoist to travel speed, I would suggest a hoisting speed of 75 feet per minute, which would give a travel speed of 150 feet per minute.

Taking into consideration the friction of the ropes through the pulleys, hoist friction and belt slippage, a fair value to assume for overall efficiency will be 65 per cent. To hoist 500 pounds at 75 feet per minute, with a hoist efficiency of 65 per cent will require 1.75 horsepower. A 1000 pound load will require 3.5 horsepower. A 3-horsepower motor is about the right size for hay hoists under ordinary conditions.

The rope speed for returning the fork should be the same as the travel speed. Hoists now on the market have a return speed of two to three times the travel speed. This is too high and often gives trouble with tangled ropes. The car also strikes the stops with too great an impact.

[1]A contribution to the symposium on rural electrification presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Amherst, Mass., October, 1929.

[2]Industrial engineering department, General Electric Company. Mem. A.S.A.E.



An electric powered hay hoist in operation

Test	Type of Drive	Distance Hoisted Feet	Hoisting Time Seconds	Hoisting Speed Feet Per Min.	Average hoist Speed Feet Per Min.
A	5 hp.-1800 r.p.m.	12	9	80	
A		20	14	85.7	
A		20	14	85.7	
A		22	16	82.5	84.7
B	Auto truck	30	13	139	
B		32	14	137	138.0
C	3 hp.-1500 r.p.m.	24	24	60	
C		25	26	57.7	
C		26	26	60	59.2
D	Two horse team	20	9	133	
D		22	10	132	
D		22	10	132	
D		25	12	125	130.5
E	7½ hp. portable farm motor-1800 r.p.m.	23	9	153	
		23	10	138	
		23	12	115	
		23	12.5	110	
		23	15.0	92	
		23	15.0	92	113.0
F[3]	7 hp. gas engine 360 r.p.m.				32.7

Differences in time of hoisting probably due to clutch slipping.

[3]This engine was not running and the hoisting speed was calculated from data taken. The drum speed was 300 r.p.m. whereas 600 r.p.m. is recommended by the hoist manufacturers.

Relation of Farm Machinery to Maintenance of Soil Fertility[1]

By C. A. Bacon[2]

AFTER making a careful study of the world's increase in population and the probable increase in the supply of foodstuffs, Sir George H. Nibbs, fellow of the Royal Anthropological Society, makes the statement that the United States is soon to face the problem of supplying food for an overwhelming population. The growth of population from 1910 to 1920 was 1.4 per cent per annum. If the growth continues at this rate in the future, the United States in the year 2000 will contain an average of 106.38 persons per square mile of territory, and at that time this country will have exceeded its limit of maintenance at the present standard of living and rate of food production. Despite the assertions being made on all sides that this country has a surplus of this and that in the way of food supplies, it remained for this eminent scientist to point out the direction in which we are traveling agriculturally. The substance of his research shows very clearly that our children will either go hungry or import part of their food supplies by 1975.

A few years ago the Hon. Frank O. Lowden was credited with making the statement in a speech in New York City that, at the rate our soils are being depleted, in 50 years more the fertility of the soils of the United States would be practically gone. There is plenty of evidence to be gleaned from the figures of the U. S. Department of Agriculture to show that our farmers as a class have never given much attention to soil building.

As an example of the steady decline in agriculture since the eighties the amount of land farmed during the peak years of agriculture in Ohio, Indiana, Illinois and Iowa, was compared with that used in these states in 1925 for farming purposes. Ohio's peak year was 1880, Indiana's, Illinois' and Iowa's was 1900. During that period these four states had 113,517,914 acres in farm land. In 1925 they had 106,147,128 acres, the loss of farm land in 1925 over that of the peak years being 7,370,786 acres. During this same period the decrease in all their farm products, both in quantity and quality, has been very marked.

The 1927-28 investigations conducted by the grain marketing specialists of the Illinois Agricultural Experiment Station showed that out of 89,741 carloads of corn handled during that year throughout all the state inspection points, there were only 740 cars, or 0.10 per cent, graded as No. 1. More than one-half of all the corn inspected was graded as No. 5 and less. One-fifth was classified as "No Grade."

The U. S. Department of Agriculture figures show that from 1880 to 1900 practically all the corn graded No. 1, No. 2 and No. 3. In those days the great percentage of corn was high grade. Today some of it is too low to grade.

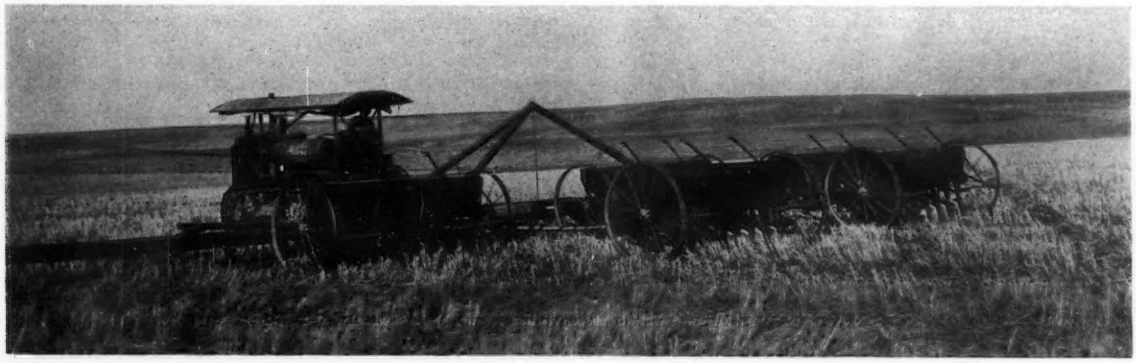
The figures quoted from the inspection of the marketing specialists of Illinois show further what one may expect in the way of finished beef, dairy products or anything else that comes from the farm. Beef and pork have long been on the decline, both in numbers and quality. Dairy cattle are now growing less in numbers. Livestock diseases and plant diseases are becoming more prevalent each year, and insects are taking infinitely greater toll of our crops than they ever have in the past history of our country.

During all this time of decline few people have given much thought to the soil as being a factor, despite the fact that our biologists, chemists and botanists have shown repeatedly that the treatment of the soil is directly responsible for many of the preventable ills of both plants and livestock.

As a matter of fact many young boys coming up on the farms at the present time, when shown No. 1 corn would not believe that it was possible for a farmer to grow such a product. There can be only one fundamental cause for all this trouble with our corn, and, that is, the soil does not have within it the substance to produce No. 1 corn. We hear people on all sides talking about changes in weather as being a factor, yet a very careful survey of the weather records of the past forty years shows that there has been practically no difference in climate from one year to another. Consequently we must look to our soils or the United States will lose its prestige as the greatest agricultural nation. We hear altogether too much about seed corn as being the limiting factor. Disease-free seed corn and virility are vital factors, but we have found in our experiments that weak seed planted in highly fertile soil produced better corn of a higher yield than certified seed planted in soil badly de-

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, Chicago, December 1929.

[2]Manager, agricultural service, Oliver Farm Equipment Company. Mem. A.S.A.E.



While it is true that the larger, more efficient farm machines make it possible to "mine" the resources of agricultural soils at a much more rapid rate, this very fact will doubtless result in drawing attention more forcibly to the dangers of soil depletion. While not primarily an engineering problem, there is no problem that challenges the attention of agricultural engineers so much as does that relating to the maintenance of soil fertility

pleted of the elements that produce good corn. We also found that certified seed planted in the highly fertile soil yielded by far the best corn from both a quality and quantity standpoint.

We have reached a time in the agriculture of this country when facts must be faced. The ramifications of this soil depletion are so wide and far-reaching that every industry is affected. Every small town in the agricultural districts is directly affected, and when the local depression becomes sufficiently large, its effect upon the larger industrial centers appears. This has been shown to be true in every country of the world since history has been written.

Today in the United States the evidence goes to show that manufacturers of farm implements are trying to make it possible for one man to travel over more acres per day in order to produce more grain. No emphasis is placed upon one man making the acre produce more with the same amount of labor or less. When we take into consideration the gradual decrease of acreage of farming land and the decrease in quality and yields per acre of our major crops, are we justified in basing any conclusions upon the single idea that the larger tool used in enabling one man to cover more acres will result in anything but failure?

The degree of success of any manufacturing enterprise is governed by the greatest amount of economical production that each worker can effect. In farming the condition of the soil determines whether or not the individual can raise enough to make it worth while. To put the matter in a very brief way, it is of no consequence whether a man uses a crooked stick, a hoe, or large capacity tools to stir up a sand bank that contains no fertility.

It took several hundred years for the Roman Empire to complete its downfall starting from the one cause of soil depletion. Had those Roman farmers the advantage of our modern farm machines the Empire would have ended sooned than it did, because one of the greatest advantages of modern tillage tools is the thorough turning and mixing of the soil in a way to give Mother Nature the opportunity to liberate a greater quanitity of plant food during the period of growth of the plant. This means that in the United States a shorter period will be required to deplete its soil.

Many of the glowing accounts of the success of tractor farming which we read in the papers today may be credited to this cause, and for that reason our boasting may be very short-lived. The length of time will depend entirely upon how long it takes to complete the depletion of the soil. All one has to do to verify these statements is to talk to farmers who have learned by experience that the tractor does enable any farmer to get more out of the soil. This sort of propaganda on the part of tractor manufacturers should be accompanied by a well-rounded program based upon soil building.

Fortunately the United States today contain farmers who are making money by keeping up their soils' fertility. These men are not complaining about hard times but are indulging in all kinds of pleasure, and are well contented with their lot. Their number is sufficient to show that it is possible to conduct farming operations on a profitable basis. A study of these farms shows the soil to be in a very high state of fertility; hence, there is every reason to believe that some sort of plan must be evolved whereby the farmers who are not enjoying prosperity at the present time may be encouraged to change their farming systems to those that bring prosperity.

It is imperative that immediate attention be given to this subject by everybody interested in agriculture. Despite the splendid work being done by the federal and state departments of agriculture, agricultural colleges, experiment stations and extension forces, and the farm press, the rank and file of our farmers are not taking advantage of their teachings. Therefore, something must be done to persuade these farmers to plan and practice systems of farming that will keep down surpluses to the minimum, increase the yield of the acre to the maximum, and, so far as possible, raise crops of high quality that can be stored to permit orderly marketing.

These things are all possible, but no one branch of agriculture can do this by itself. It requires the combined efforts of all who are interested in any phase of agriculture. In addition to agricultural research and extension work, manufacturers of farm implements, bankers and merchants, particularly implement dealers, must engage in a concerted effort to help farmers get on a solid footing.

So far as the agricultural engineers are concerned, the time has come when the field must broaden beyond the scope of mere farm tool operations.

It is interesting to note the mad scramble to build machines to help the farmer out of his troubles. Anyone who has followed the history of farm implements knows that the fundamental parts of tillage machines were not changed much except to increase capacities, until the latter part of the nineties, which time parallels that of the beginning of the decline in our agriculture. Today contrivances of all kinds are appearing on the horizon with millennium-like claims made for them. Whether these devices will endure or go the way of the countless numbers that have come and gone during the last thirty years depends entirely upon their economic worth.

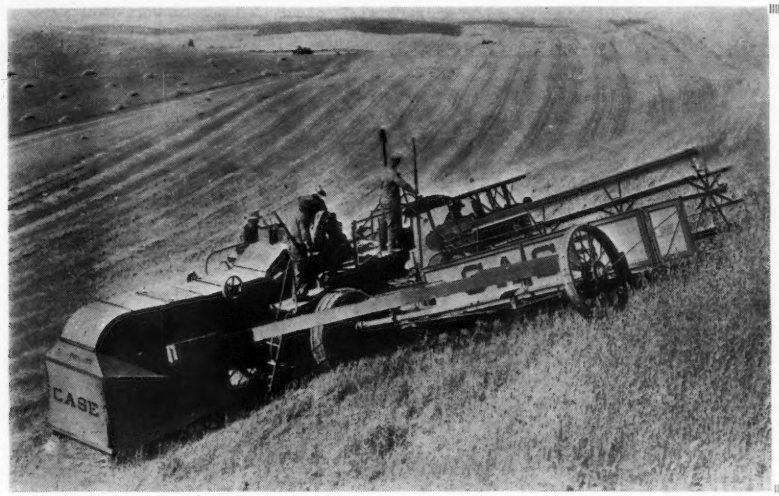
The revival of the combined harvester and thresher was heralded as a saver of money in harvesting. The cost per bushel was slashed right and left. Then came the question of excess moisture. Three years ago the railroads in Dallas, Texas, refused cars for combined grain shipments. The net result thus far shows additional appliances, swathers, and grain driers, as being necessary. If all this proves to cost more to harvest grain than it did with the old system of harvesting and threshing, the combine will pass on with the rest that have caused manufacturers to spend millions of dollars.

To date none of the farm implement manufacturers have evidenced any interest in soil building as a possible help in producing grain that could be combined without the necessity of artificial drying. It is well worth the effort to do some experimenting to prove whether or not soil building might produce a grain with a straw that will stand up better than the present straw, and have kernels that will ripen enough without shelling to make unnecessary artificial drying processes such as are being discussed and experimented with at the present time.

One of the peculiar phases of this situation is that some people are trying to show that drying the grain artificially increases the protein content, and this, too, on top of the statement coming from Canada that the wheat in that country does not show the same high protein content as formerly. The reported reasons are the kind of wheat now being sown and poor soils.

The corn picker is another new tool. Its principal drawback is down corn. Down corn can be minimized very greatly by soil building. A cultural practice that eliminates disease and insects and builds soil fertility of the kind that promotes a sturdy root growth helps to produce a stalk that resists bad weather conditions, and in this way greatly facilitates the use of the corn picker. Therefore, the remedies of the major troubles with both combine and picker are right in line with the soil building program that means greater soil production of the high quality produce.

Speaking in terms of the agricultural economist, farm production costs are too high. They must be lowered. So far as implement manufacturers are concerned, each has a formula based entirely on what he has to sell as a panacea for high production costs. The most common one is that large capacity tools which enable one man to cover larger areas in any given time lowers cost of production. This contention is based upon lowering the operation cost and nothing is said about the cost per bushel. The assumption seems to be that low production



Some of the difficulties in the harvesting of the grain crop, created by the introduction of the "combine," especially that of damp grain, may possibly be overcome by building up soil fertility as a help to producing a grain with straw that will stand up better and with kernels that will ripen sufficiently without shelling

cost per acre is the vital factor, despite the fact that in the end the cost per bushel or pound determines whether the grower makes or loses money.

The U. S. Department of Agriculture Yearbook for 1927 throws illuminating light on this subject. A wheat cost production table by states gives the cost of growing wheat per acre in South Dakota as $12.05; the cost per bushel as $1.72; and the average acreage per farm as seventy-four. Ohio gave as the cost per acre, $24.72; the cost per bushel, 95c; and the average acreage as nineteen. The Ohio farmers spent $12.67 more per acre for growing than did the farmers of South Dakota, and yet grew the crop for 70 cents per bushel less. South Dakota gave seven bushels per acre as the yield, and Ohio, 26 bushels. These figures show that a great deal besides running over the fields with farm tools is concerned. People who delight in analyzing figures may ponder at length on these results. One of the questions is the law of diminishing returns. How much extra cost can be put on the acre, and on what items shall it be expended?

Due to the entirely different methods employed in growing wheat in these two states, another interesting question arises: Will the Ohio system work in South Dakota? It is very doubtful whether the Ohio farmer would be interested in South Dakota methods. Dollar wheat would have given the Ohio farmer a profit of $1.30 per acre, or $24.70 for his whole crop, and the South Dakota farmer would have lost $5.04 per acre, or $322.96 on his seventy-four acres.

These figures also bring forcibly before the agricultural engineer the question of what constitutes a fundamentally sound farm operation. Any farm implement operation may be said to be fundamentally sound or efficient when that operation coordinates with the work previously done and will coordinate with that which may follow to make the sum total of all the operations produce a profitable crop. The farmer is not gaining anything if one operation performed in one way at a lesser cost than another brings about a higher charge for the other operations. Hence, there is great need for deep study into the subject of coordination of farm operations.

It is quite apparent from these figures that the 518 bushels of wheat the South Dakota farmer dumped on the market helped to keep down the price the Ohio farmer might have received for the 494 bushels. This illustrates a fundamental marketing problem based on production. Is this good business for anyone, since the farmer who produces at a loss is disastrous to himself and helps to reduce the profits of those who do operate at a gain? And will it be possible for farmers to cooperate in marketing grain with such wide differences in production costs as now exist?

The only factor in farming over which the farmer has no control is climate, and it has been shown time and time again that the farmer can treat his soils to reduce the evils of climate to the minimum. This is essentially a part of sound farming. There are those who will say that the small yield of wheat per acre in South Dakota was due to drought. Figures taken from the U. S. Weather Bureau records show that this was not wholly true, because the temperature of these two states during the growing of the wheat was practically the same, and the rainfall in South Dakota would have been ample to minimize the drought which did happen in that state a couple of weeks before harvest, had the soil been properly treated. Hence, it is perfectly legitimate to say that the reason for South Dakota's failure in raising wheat was due more to a system of farming than to weather influences.

The increase in the number of operations used to grow and harvest crops presents a cost problem that should be investigated thoroughly. New ideas in tillage tools are springing up everywhere. Some of them are designed to meet conditions that should not exist. The different devices of all kinds to fight weeds offer a striking example. They came into being with weed increases. Today thresher manufacturers are obliged to put recleaning devices on threshing machines to stop market dockage of wheat. The irony of one phase of this problem is well illustrated in an incident which happened six years ago. One of our good farmers lost forty perfectly good shoats averaging 350 pounds. He attributed the deaths to cholera but was suspicious. We examined the feed and found wheat screenings from Minneapolis mills containing enough mustard seed to kill twice the number of hogs that ate this concoction. On the one hand, the miller screened the seeds out of the wheat and sold them to feed livestock, which died from the evil effects, and to bring about this result manufacturers spent thousands of dollars in research, designing and manufacturing to perfect these recleaning devices which enabled Minneapolis millers to protect humans and poison farmers' hogs at a profit to themselves. If farmers practiced soil culture of the right kind, the necessity for all this extra machinery would not exist.

As a body of technical men, the American Society of Agricultural Engineers has an opportunity to help farmers reduce their cost of production and to grow high-grade profitable crops, first, by realizing that farm machine operations are but a means to an end, and, second, by encouraging systems of farming that produce high-grade crops and lessen the necessity for so many different operations.

Combine Performance in Germany[1]

By Nordahl L. Wallem[2]

REPORTS of the successful use of the combine in foreign countries and the observation of their operation in the United States and the Argentine by German agriculturists and agricultural engineers aroused in Germany the wish to test these machines under German conditions. Especially encouraging reports came from states east of the Mississippi River where the climatic conditions are similar to those in Germany.

The first combine in Germany operated on the farm of Graf Bismarck-Varzin in Pommern in 1927. In 1928 the Reichskuratorium fur Technic in der Landwirtschaft purchased a combine for experimental purposes. And the same year five combines were purchased by farmers so that experimental data was available from seven machines. By the summer of 1929 the number of combines had increased to fourteen. Eleven of these belonged to private individuals and three to the Reichskuratorium. Two machines were purchased on approval.

These combines were drawn by tractors having at least 30 belt horsepower. They were equipped with 12 to 14-foot cutter bars and separate engines. Sacking attachments were only used in those cases where no adequate storage facilities were at hand to facilitate the use of grain bins and trucks or grain wagons. Most machines used the weed screen. The straw was put in rows or heaps to be collected later. Straw spreaders were hardly ever used. The combines harvested wheat, oats, summer barley, rye, winter barley, mustard, peas and rape seed. Since the acreage devoted to rye is three or four times greater than that devoted to wheat, the tests were designed primarily to determine the combines, efficiency with rye. The results of the tests in 1928 were not very favorable, but in 1929 the combines harvested rye satisfactorily. The long straw (wheat up to 5 feet, rye up to 6 feet) and the heavy yields (wheat often 52 bushels per acre, oats and barley about the same, rye up to 35 bushels per acre) did not make the work of the combine any easier. There are also grown in Germany a few varieties which are especially well adapted to the combine because they have short stiff straw and are at the same time shatter-proof, easy to thresh and high in yield. Up to the present these varieties are not widely used.

It is customary in Germany to cut the grain 4 inches from the ground in order to have as much straw as possible for bedding and feeding the cattle. Therefore, the combine was seldom set to cut higher than 12 to 14 inches. Cutting the straw long means fewer acres cut per hour. An attempt was made to save the chaff. This was technically possible, but the chaff proved to be so damp that it could not be stored.

The dampness of the straw which may be as high as 50 per cent at the beginning of the harvest time causes many difficulties by clogging up the cylinder. Damp, high weeds cause less trouble in the cylinder because they are easily cut.

Water content in the combine-harvested grain is usually higher than 14 or 15 per cent. Under unfavorable weather conditions grain has to be ventilated or artificially dried. The average water content in all grains was 16 to 18 per cent; in oats, 16 per cent; in barley, 17.5 per cent; in wheat, 16.2 per cent; and in rye, 18.1 per cent. It could not be determined in these two years of experiment whether abnormally high water content in the grain raised the threshing loss of the machine. The tests for germination, milling and baking qualities showed that combined grain is not inferior in quality to grain harvested in any other manner.

Because the percentage of grain loss in harvesting had never been exactly determined, experiments were conductd in 1929 to secure data on this. The amount of loss depended on the condition of the grain as it stood in the field and on the adjustment and care of the machine. The cutter bar loss ranged between one-half to three-fourths of the total loss. Heavy weeds and high water content in the straw decreased the efficiency of the straw shakers. On the whole, the combine showed an average grain loss of only 4 to 6 per cent, while grain harvested by other methods showed an average loss of 8 to 10 per cent or even more.

The average acreage harvested by the combines was, in 1929, 250 acres. The harvest season covered twenty-three working days of about 6.5 hours each. Threshing capacities ran from 33 to 110 bushels per hour. In stationary threshing with the combine in the barn or from the stack a capacity of 93 bushels per hour was reached when the machine was equipped with a self-feeder. Wear and tear on the machine was greater during the stationary work than during the work in the field. Longer straw and higher yields than are common in America reduced the number of acres cut per hour and increased the fuel and labor requirements.

A windrow and pick-up attachment was used in Germany for the first time in 1929. A distance of 10 inches between the rows proved to be too wide to bear the windrow and to allow it to be satisfactorily picked up. Rows 6 inches apart and stubble of one-third of the total length of the grain proved satisfactory. In spite of two heavy rains the water content in the grain dropped from 25.4 to 13.7 per cent and the water content in the straw from 52.8 to 15.9 per cent. This means that grain in the windrow dried more rapidly than grain in the shock. The green weeds also dried rapidly, making the threshing easier. Whether or not it is possible with the windrow attachment to begin the harvest earlier than is now customary, has not yet been determined. The straw which had lain seven days in windrows was dry enough to stack or store immediately after the threshing. This could not be done in the case of straight combining because the straw always proved to be too wet. Only a few farms could afford to spread the straw over the field and plow it under. The others were obliged to find a means, however difficult, to store it.

The two-year test, although it has been favored by especially dry harvest weather, has proved that the use of the combine in Germany is technically possible. However, it is not so clear that the combine will be as efficient and economical in operation under the difficult German farming conditions as it has proved in certain foreign countries where agriculture is on a one-crop basis, and where the harvest weather is usually more favorable. The combine can be successfully used on large farms in Germany where a large acreage of grain is grown and where labor is usually scarce. These farms must, however, give very careful consideration to such problems as the variety of grain to be planted, the efficient collecting of the straw and the proper storing of the grain. The farmer must arrange his sowing time for the different grains in such a way that the harvest continously follow one another. The final decision as to whether the combine will cut harvest cost more than the all-steel thresher, which is better adapted to the German farming conditions, can only be answered after more extensive experiments carried on over a longer period of years.

---

[1]A contribution from the Reichskuratorium fur Technic in der Landwirtschaft (Germany) which summarizes the salient points of a detailed report (Bulletin No. 9) on these investigations

[2]Engineer in charge of combine investigations, Reichskuratorium fur Technic in der Landwirtshaft.

Strength Tests of Sewed and Riveted Leather Splices

By J. Grant Dent[1]

TO MAKE a good hand-sewed splice in a leather strap requires considerable knowledge and skill. Quite a number of pieces of equipment are needed also, such as a sewing clamp, awl, needles, thread, wax, knife, etc. The question which nearly always arises is whether the hand-sewed splice is enough better than the riveted splice to make up for the extra time, trouble and expense involved in its making. If rivets are to be used, which kind is best and how many are needed?

In order to better answer these questions, tensile strength tests have been made. Results of the tests are shown in the accompanying graph and table. Pieces cut from three sets of one-inch standard leather team lines were used. Ten tests were made of each splice. In starting the series, ten 12-inch pieces were cut and tested for the average strength of the unspliced leather. The results of Test A are shown in Table I and Fig. 1.

The hand-sewed splices were made with a 3½-inch lap, each piece beveled 1¾-inch from the end, the top strap on the flesh side and the lower strap on the hair side. They were sewed with a waxed thread made from four strands of harness thread, using a two-inch awl blade and No. 2 harness needles. Nine of the hand-sewed test pieces failed at one end of the splice where the awl pierced the leather for the last stitch. One failed about two inches from the splice. The sewing showed no signs of strain in any of the splices.

The machine-sewed splices were cut from the lines as they came from the factory. Five of the ten tore the threads. The other five failed at the end of the splice similar to the hand-sewed splice.

The leather was prepared the same for all the riveted splices as for the sewed. No. 12 copper rivets and burrs were used in Tests D and E. All the test pieces in which three copper rivets were used, failed at one end of the splice at the rivet hole. The leather tore out in all those with two rivets.

No. 1 tubular rivets and a riveting machine were used in Tests F and G. In all the tubular rivet tests the rivets either pulled through the leather or tore out both with two and three rivets.

The split rivets were 9/64 inch in diameter, ½ inch long and were driven through the leather, then clinched. The results are shown Tests H and I.

All tests were made on a Riehle Brothers testing machine. Fig. 2 shows the nature of failure most typical of each type of splice tested.

[1]Instructor in agricultural engineering, University of Minnesota. Mem. A.S.A.E.

TABLE I. Tensile Strength Tests of One-Inch Standard Team Lines*

Splice	Average pounds	Per cent of normal strength of unspliced Strap
A, unspliced strap	845	100
B, hand sewed	665	79
C, machine sewed	635	74
D, 3 copper rivets and burrs	470	56
E, 2 copper rivets and burrs	325	38
F, 3 tubular rivets	370	44
G, 2 tubular rivets	270	32
H, 3 split rivets	280	33
I, 2 split rivets	190	22

*Ten tests were made of each splice, in which a 3½-inch lap was used.

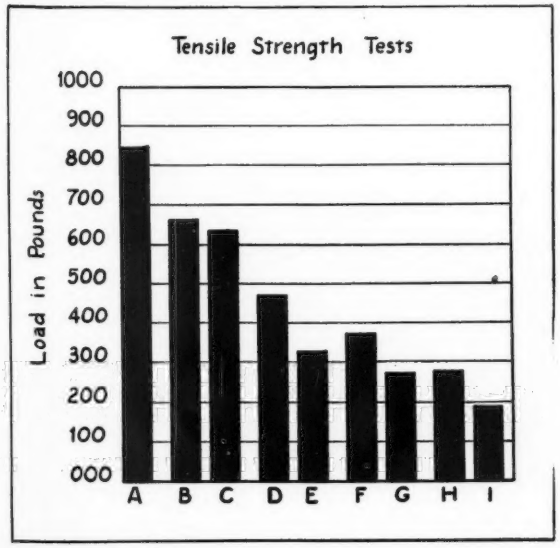


Fig. 1. Graphical representation of the average strength of each series of members tested: A, unspliced strap; B, hand-sewed splice; C, machine-sewed splice; D, three copper rivets and burrs; E, two copper rivets and burrs; F, three tubular rivets; G, two tubular rivets; H, three split rivets; I, two split rivets

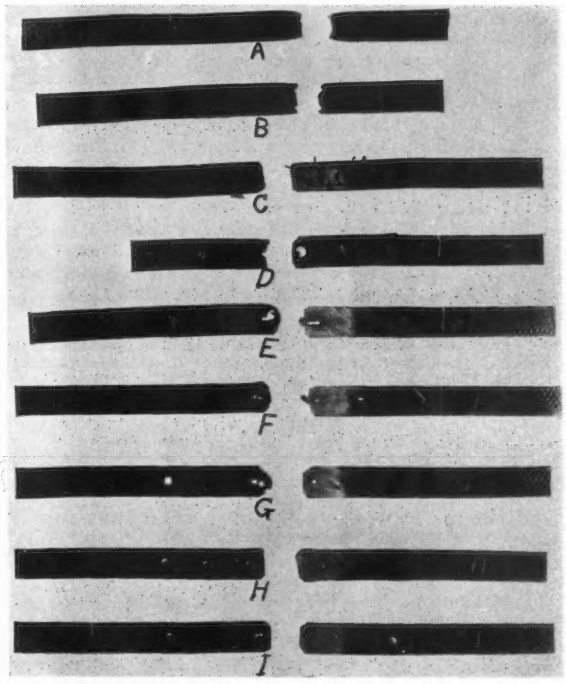


Fig. 2. Typical failures in each series of tests. The legend is the same as for Fig. 1

SUMMARY

There is considerable of an advantage in the sewed splice over the riveted, not only in strength and appearance, but also in that the ends of the leather are securely held down, preventing their being caught by some obstruction.

In the riveted splice the corners of the strap are apt to curl up even though the rivets are placed near the end. The failure of the threads in some of the machine-sewed splices is due to the threads from each side being looped together in the center, whereas in the hand-sewed splice the two threads extend entirely through the leather and are independent of each other. The hand-sewed splice is weaker than the unspliced leather only because of the holes made by the awl at the ends of the splice.

Because of the larger head and burr, copper rivets make a stronger splice than tubular. Although the tubular rivets cut a slightly larger hole through the leather than was required for the copper, the rivets pulled through in every instance while the leather failed in all tests where three copper rivets and burrs were used. The tubular rivet cuts the surface of the leather to some extent when clinching probably causing some loss of strength. It seems to be the general opinion that split rivets are more suited for other uses than for leather splicing.

It is interesting to note that the strength of the leather did not vary according to the thickness. Some of the strongest specimens were the thinnest.

Rural Line Construction[1]

By F. la T. Budgett[2]

THE plan on which the rural customer pays for his electric service is generally based on the annual charges, both fixed and operating, against his share of the line. It is clear that due to the small number of customers per mile it is desirable to keep down the annual cost. This at once suggests the use of a less expensive type of construction than that used in cities.

The farmer may think that the simplest way out of this is to use poles of local wood, with small wires and the very simplest type of insulators and other equipment. He can see, perhaps, no reason why money should not be saved by using quite short slender poles, with no preservative treatment; by digging shallow holes, omitting proper guys, and generally paring down the first cost to rock bottom.

Unfortunately he does not realize what the effect of such a policy would be on his service. He wants ranges and toasters to heat up quickly; motors to develop their full power (especially the 5 h.p. motor used on the bigger jobs such as silo filling). Small wires mean excessive losses and poor service.

The customer wants dependable service which will not be interrupted by every high wind or thunderstorm. A line of scrimped construction is poor insurance against trouble. And when it comes, the distance which the repair crew often have to cover makes the restoration of service slower, more difficult and more expensive than in the city.

Such methods as have been referred to may keep down the first cost, but will almost certainly result in high maintenance costs, and do not solve the problem. What is the alternative? Let us economize by all means, but only in ways which will not sacrifice safety and satisfaction, and which will not merely reduce the fixed charges at the expense of increased operating costs. Let us build lines which by their reliability will continue year after year promoting good will between the customers and the company.

Since the cost of a line depends largely on the number of poles, a very promising plan is to use longer spans. Several materials have been introduced which are of great assistance along this line, since their ultimate strength and safe working tensions are higher than those of a copper wire of equal conductivity. Thus larger spans can be employed with the same sag and ground clearance.

Extensive study has shown that with the aluminum cable, steel reinforced construction, other things being equal, a saving of from 10 to 12 per cent in first cost may be expected. Additional poles can be set between the others, making 160-foot spans, to take care of additional wires and services when increased business makes it necessary. There are, of course, cases where due to winding roads, bad tree conditions, etc., full advantage cannot be taken of these longer spans. In such cases, copper conductors with 250-foot maximum spans on 30-foot poles are recommended.

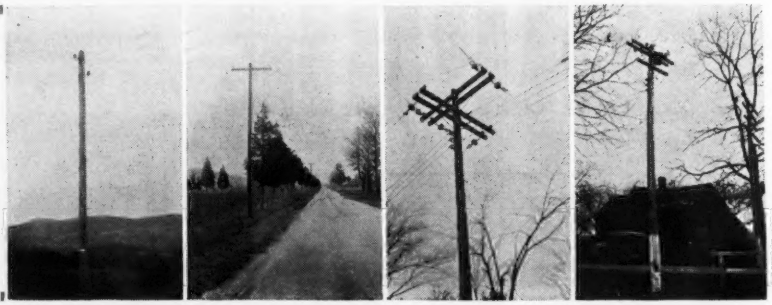
In this regard it should be remembered that cost reduction is not in the hands of the power companies alone. Farmers and residents along rural highways can help very materially by adopting a progressive attitude in regard to tree-trimming and rights-of-way, which will help to make long-span construction possible. The placing in the way of unnecessary difficulties works in the long run to their own disadvantage as well as that of their neighbors.

Where highway lighting is anticipated (and this will be increasingly frequent as time goes on), 35-foot poles are desirable, and spans should not exceed 300 feet on straight sections or 200 feet on curves.

Aluminum cable, steel reinforced, with its new tools and technique met, like all innovations, with some opposition when first introduced, but its use is now becoming well established, and is giving the results expected from it. However, experience with it has not of course extended over many years, and it is not by any means the only possible material in economical line construction.

[1]A contribution to the symposium on rural electrification presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Amherst, Mass., October, 1929.

[2]Engineering department, New York Power and Light Corp. Assoc. Mem. A.S.A.E.



(Left to right) An old type of construction. An aluminum cable, steel reinforced line with 320-foot span. Corner and junction construction with A.C.S.R. A transformer pole with secondaries on racks, A.C.S.R. construction

Stucco as a Decorative Building Material[1]

By W. G. Kaiser[2]

THE use of plaster or stucco as an exterior wall covering dates back hundreds of years. According to our most authentic records, plaster was first used to fill the chinks and cracks in the crude dwellings of primitive man. The "wattle and daub" or mud plastering of the ancient Briton is an example of the early use of plaster. Its sole purpose was to make the walls of this abode more nearly weathertight.

It is only in comparatively recent years that the decorative value of stucco has been appreciated in this country. In European countries, however, it has enjoyed wide popularity for several centuries. In fact many of the textures and finishes which are so popular here today were imported from the nations of Europe. Even in Europe the textures were originated quite by accident rather than by design. The different surface markings which characterize the different finishes were the result of the tools used. Under these circumstances each country developed a more or less distinct technique in applying the stucco. This resulted in the production of finishes which have become identified with the architectural styles of the different countries. For example, there are the Italian, French, English, Spanish and other finishes.

This country however, can claim credit for the general introduction of color in stucco surfacings. Until recent years little or no attention was paid to coloring effects in stucco. In fact it was not possible to achieve a multiplicity of colors with the materials formerly available which were constituted almost entirely of natural colored aggregates.

Mineral pigments are now chiefly relied upon for color and make available a variety of effects ranging from quaker conservativeness to the bizarre. The use of bright colors may produce offending effects when not wisely blended with architecture and landscaping. The successful stucco specialist of today therefore must not only be a skillful and able workman, but something of an artist as well, with an eye for color harmony and the beauty of contrast in light and shadow.

As mentioned before the textures in Europe were to a large extent accidental and the inevitable result of the type of tools employed. It is in America that various textures were intentionally reproduced to create individuality in treatment and colored to produce harmonious results. A very thin coat in first trowelled on the wall. This insures uniform color over the entire surface, even though the dash coat may not give complete coverage. Small quantities of mortar are then dashed on, with quick strokes of a whisk broom. Since a splatter-dash coat hardens rapidly, not more than thirty square feet of wall should be covered at a time and then finished before hardening occurs.

Finishing is best accomplished by placing the trowel flat against the partially set dash coat and drawing it evenly across the face of the wall from left to right. A smoothing return stroke may be made to erase possible trowelmarks. Variations will occur in the texture according to the time elapsing between dashing and trowelling. Consequently this time should be constant for uniform appearance.

Italian Texture. This is created with a splatter-dash finish applied on a thin undercoat.

French Trowel Texture. This is a full swept texture, finished in the typical French grey shade, and truthfully displays the technique of application.

English Texture. The shades generally used are the more sombre tones of dark red or grey which are in keeping with the architectural style, enchancing the soft, heavy texture so appropriately used with this manner.

English Cottage. The shading is accomplished by feathering the material into minute, irregular weavings and surfaces with the edge of the trowel.

Modern American. This is produced by lightly drawing a board across the trowelled surface. This rough texture of buff color can be given an interesting tapestry effect by lightly drawing across the surface a brush with a colored stain.

Californian. In the development of the California texture a rough trowelled surface is partially smoothed by rubbing with a piece of burlap. The warmer tints of tan or buff harmonize well with it.

Spanish. This is produced by using a trowel with rounded corners. The polychrome effect may be produced by having batches of differently colored stucco on the hawk at one time.

Mexican. It is similar to the Spanish texture so far as method of application and appearance goes.

Moorish. A texture produced by using a small trowel with rounded corners. It represents an extreme both as to color and texture, being an example of what can be done by irregular spotting. It corresponds to use of ornament by the Moors, with a lighter tone of a primary color as shading.

Colonial. Devoid of textural ornamentation, this sand-floated Colonial finish is of sufficient body to hold the lighting tones thrown upon it. The lighter tints are the rule, such as white, ivory or occasionally a pale cream yellow.

Travertine. This texture is one of the many variations in a representation of travertine stone, a popular pitted marble commonly imported from Italy.

[1]Paper presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Amherst, Mass., October, 1929.

[2]Agricultural engineer and assistant manager, cement products bureau, Portland Cement Association. President, American Society of Agricultural Engineers.

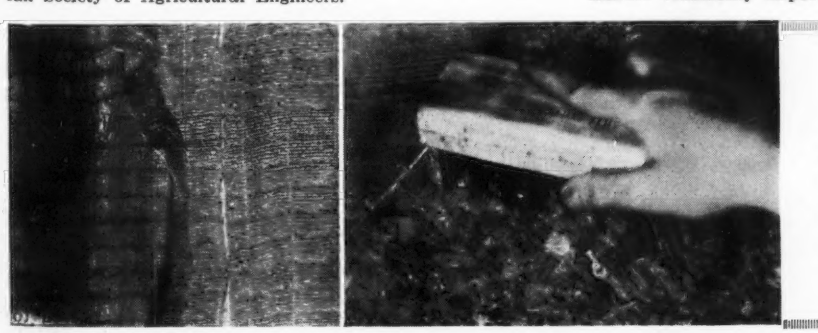


Fig. 1. (Extreme left) Rough surface produced on monolithic concrete by the use of special burlap. Fig. 2. (Left) Another method of preparing concrete to receive stucco. A special compound painted on the forms retards hardening in the surface concrete, permitting the aggregate to be exposed by brushing

BASIC REQUIREMENTS

Just as a substantial foundation contributes to the durability of the superstructure so do the base coats of stucco have an important bearing on the lasting qualities and the beauty of the stucco finish. Any discussion of stucco as a decorative medium would be incomplete without considering the foundation coats and the under structure itself. A stucco house covered with unsightly cracks is unfortunately not an uncommon sight. Troubles of this sort are frequently due to an unsound or shifting frame, unsuitable base or improper handling.

Success in the application of stucco requires that it be used either as a material that is bonded to and becomes an integral part of the base to which it is applied, such as stucco on masonry and monolithic concrete, or as a thin reinforced concrete slab anchored to the structure but not itself forming an integral part of the backing. An example of the latter is stucco applied on metal reinforcement over frame structures.

Walls of concrete masonry, hard-burned clay tile and hard or medium clay brick are good bases for the direct application of portland cement stucco. The surfaces of the units should be rough and free from grease, soot, dirt and other foreign matter to insure a good mechanical key and satisfactory bond. Portland cement mortar should always be used in laying up masonry walls to be stuccoed and the joints struck flush or evenly raked. If these precautions are taken satisfactory bond will result and a satisfactory job of stuccoing will be obtained.

Where stucco is used as an integral part of the base as on monolithic or masonry surfaces it is essential that the base provide a satisfactory key. On masonry units the surface is usually rough enough to provide a satisfactory bond but in the case of new and old monolithic walls special roughening is usually necessary. On old monolithic surfaces this may be done with bush hammers or other special tools or as an alternative, the walls may be scrubbed with a dilute solution (about 1-6) of muriatic acid. After the acid treatment the wall must be thoroughly washed with water.

New monolithic concrete can be roughened with a heavy wire brush or special scoring tool if the forms are removed shortly after the concrete is self-sustaining.

A rather recent method of providing rough surfaces on monolithic concrete is by the use of a special large mesh patented burlap placed on the form surfaces. After forms are removed the burlap is stripped off as shown in Fig. 1, leaving a deeply scored surface.

Another method of preparing monolithic concrete surfaces is through the use of special compounds painted on the form faces. These compounds, said to be composed of alumina-silicates suspended in shellac, retard hardening of the surface concrete. The desired roughness is then secured as illustrated in Fig. 2 by brushing off the soft surface material after the forms have been removed.

Metal Reinforcement. Where stucco is applied to wood or steel frame structures of the open or sheathed type it is the best practice to use metal reinforcement. It is very important that the structure be well braced and rigid. Many of the cracks seen in stucco buildings are structural cracks caused by poorly braced frame construction. Needless to say, the presence of such cracks robs the most artistically planned stucco job of much of its beauty.

In employing metal reinforcement over framework the reinforcement should be furred out at least ⅜ inch from the wall so that the stucco can be forced behind the metal, completely embedding it. This provides a thin slab of reinforced concrete over the frame structure and a sound base for the textural effects to follow.

Fig. 4 illustrates several types of furring nails commonly used and Fig. 3 shows successive stages of stucco and metal lath construction.

Uniform Suction. Before discussing the application of the scratch, brown and finish coats it will be well to consider the matter of suction.

Suction, as used in plastering terms, is the tendency of the base-coat to absorb water. Over a surface to be plastered suction must be controlled as nearly uniform as possible by evenly dampening the base coat area about to be plastered. This regulates the amount of water that will be immediately drawn from the applied coat. Excessive variation in the degree of suction may give the finish coat a blotchy, unsightly appearance.

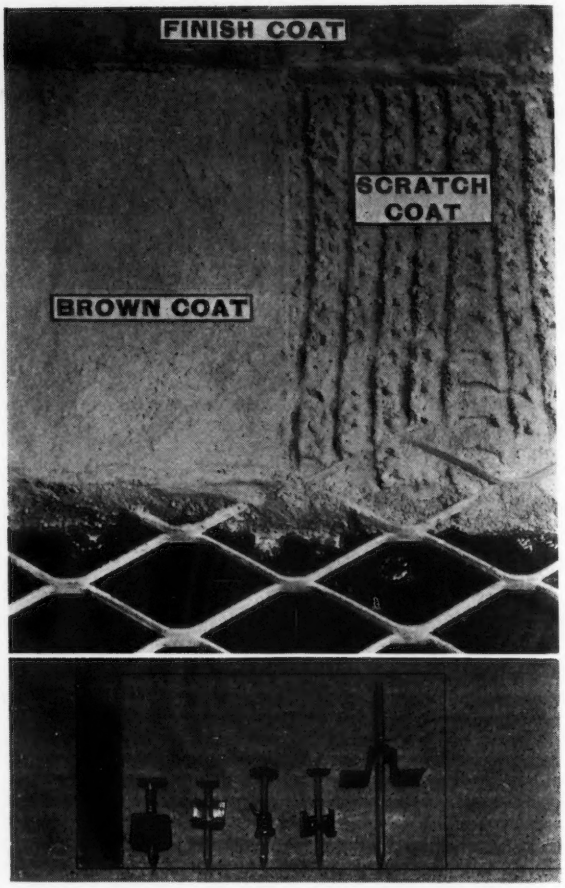
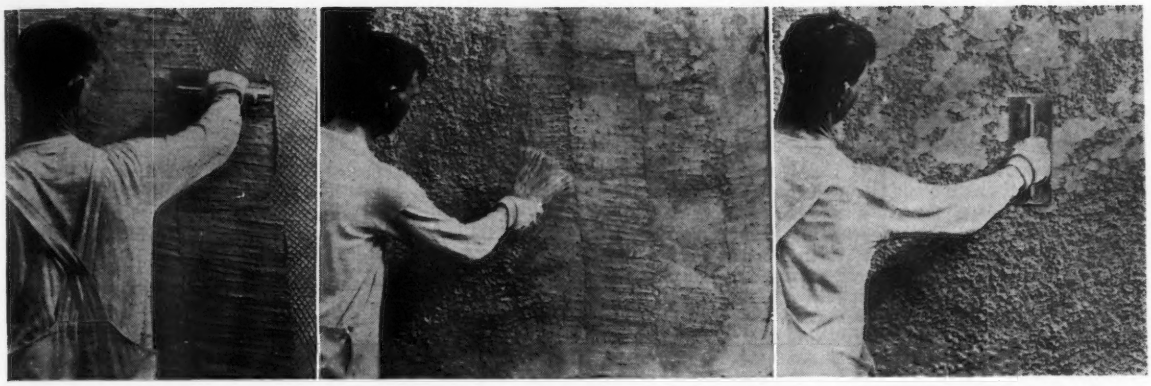


Fig. 3. (Top) Proper construction for stucco on metal reinforcement. Note the backing of waterproof building paper, reinforcement held at least ⅜ inch away from the backing with furring nails, and the scratch coat filled in solidly behind the metal. Fig. 4. (Bottom) Several types of furring nails

Proportions and Application. On monolithic surfaces, the first or "scratch" coat is dashed on unless the surface is sufficiently rough to insure adequate bond for the scratch coat when applied with a trowel. This mortar should be of a mushy consistency and composed of one part portland cement to one and half parts of aggregate.

Usual recommended proportions for scratch and brown coats are one sack of portland cement and three cubic feet of aggregate with not to exceed ten pounds of hydrated lime added to give the mortar increased plasticity. Aggregate should be clean and well graded from fine to coarse and should all pass through a No. 8 sieve with approximately 5 per cent retained on a 100-mesh sieve. Measurements of materials must be accurate and all batches proportioned exactly alike.

Before describing the second and third coats it will be opportune to say a few words about curing. Portland cement mortar must be cured properly to insure maximum strength and durability. Durability might be described as the hidden beauty of stucco. Without it, surface beauty is only transient. Each coat should be kept damp continuously for at least two days and then allowed to dry out completely before the succeeding coat is applied.



Development of the Italian or travertine texture Fig. 5. (Left) Shows application of the thin backing coat. Fig. 6. (Center) Application of the spatter dash. Fig. 7. (Right) Trowelling the dashed surface

"Haste makes waste," is a true maxim for the plasterer who "doubles back" too soon.

The second or "brown" coat, is applied to the properly cured and dried scratch coat, similarly in all cases regardless of the type of backing to which the scratch coat has been applied. Before starting to apply the second or "brown" coat, the surface of the scratch coat is dampened evenly to produce uniform suction after the same manner as the scratch coat. The brown coat is approximately ⅜ inch thick. It is brought to a true, even surface and then roughened with a wood float to provide bond for the finish coat.

Before starting to apply the finish coat, the brown coat is dampened evenly to provide uniform suction. Wherever possible, textures should be applied from top to bottom in one operation to eliminate joining marks which would detract from the appearance of the job. Work should preferably be planned so that the finish coat is applied to the shady side of the building to prevent undue loss of moisture.

Finish Coat. It is recommended that finish coat stucco already blended and colored, be purchased from a reliable manufacturer in preference to using job mixed materials. Finish coat stucco that will deliver uniform color results is a product of precise plant methods and is difficult to obtain by hand methods of mixing.

Where it is necessary to use job-mixed finish coats, approximately the same proportions should be used as in the base coats. The aggregate may be somewhat finer and should not exceed 15 per cent on a 14-mesh sieve.

Mineral Pigments. Proper proportions of mineral pigments are determined by experiment. In general, the amount of coloring materials should not exceed 6 per cent of the weight of cement. White finishes are obtained by using white portland cement and light-colored aggregate such as crushed marble or white silica sand.

Materials should be mixed to a uniform color before water is added and then wet-mixed to plastering consistency. Machine mixing usually gives greater uniformity and is preferable to hand mixing.

If the job-mixed finish coat is to be colored, it is advisable to buy colored cement. This commercial product has the color already ground into it and eliminates the difficult operation of mixing the pigments and cement on the job. When it is necessary to mix the cement and mineral pigment on the job it is recommended that a ball mill be used for the purpose.

A general guide for the selection of coloring materials is as follows: For buff, use yellow ochre or yellow oxide of iron. Red oxide of iron may be added in small quantities for the deeper buffs. For brown, use burnt umber or brown oxide of iron. Yellow oxide of iron may be used to lighten this color. A mixture of red oxide of iron and yellow oxide of iron may be substituted for the burnt umber or brown oxide. For gray, use small quantities of black oxide of iron, manganese black, or germantown lamp black. For green, use chromium oxide. Yellow oxide of iron may be used to reduce the harshness. For pink, use small quantity of red oxide of iron. For rose, use red oxide of iron. For cream, use yellow oxide of iron in small quantities. For white, use white portland cement.

The evolution of textures, modern day methods of reproducing them and the importance of harmony in color, texture, architecture and landscaping have been discussed. The builder should avoid inappropriate textures and colors. For example, a Moorish or Italian type of architecture is manifestly unsuited for the average American farm house. Such finishes would not be in keeping with the environment. In the city much geographic departures are more permissible because the entire property unit is contained on a relatively small parcel of land.

Finishes in keeping with rural surroundings are early American, Colonial and French, the latter type having been evolved from the country districts of France.

Portland cement stucco offers such a wide variety of textures and colors that no particular difficulty need be encountered in selecting a finish that will be in keeping with architectural style of the structure built and in color harmony with its surroundings. When technique of application is in accordance with accepted practice, results will be thoroughly satisfactory.

Engineers Increase Problems of Government

"WITH the development of our great national tools —our engines, our railways, our automobiles, our airplanes, our steamships, our electric power and a score of other great implements, together with the supplies of material upon which they depend, the engineer has added vastly to the problems of government, for government must see that the control of these tools and these materials are not misused to limit liberty and freedom, that they advance and do not retard equality of opportunity amongst all our citizens.

"These great discoveries and inventions have brought great blessings to humanity, but they have multiplied the problems of government and the complexity of these problems progresses with the increase of our population. Every county government, every municipal government, every state government, and the Federal Government itself, is engaged in constant attempt to solve a multitude of public relationships to these tools which the engineers by their genius and industry constantly force to the very doorstep of government. And in solving these problems we have need for a large leavening of the engineering knowledge and engineering attitude of mind and engineering method. —From address of President Hoover before 50th Anniversary Meeting of the American Society of Mechanical Engineers.

The Electric Brooder as an Ideal Power Load[1]

By A. J. Van Schoick[2]

FOR the utility the electric brooder is an ideal load. It comes in the spring of the year when there is a falling off in the usual load on the hydro-electric system. The poultryman discontinues lights on his poultry at this time. The brooders keep his load curve up. The demand is small, usually from 300 to 600 watts each. This is an intermittent load 24 hours per day about 50 days per brood. Many of the brooders will be used for two broods of chicks. The consumption may be estimated at one kilowatt-hour per chick, depending somewhat upon the type of brooder used. A utility should recommend the least expensive brooder, from an operating standpoint, consistent with good brooding practice. However, good brooding should not be sacrificed to low cost of operation.

Electric brooders meet little sales resistance. During the past year with little effort ten per cent of the farm customers of one utility were sold electric brooders. These brooders had a total capacity of 13,900 chicks. At 3 cents per kilowatt-hour the estimated revenue based on one brood for the season would be $417.00. Many of these brooders were used for two broods. They cannot be compared with washing machines yielding an estimated return of $2.00 per year and vacuum cleaners at the same rate. Mention should be made here that washing machines, cleaners and electric ranges are considered luxuries by many farm people. To a poultryman a brooder is a necessity and a money maker. Show him a product with good operating characteristics and he will welcome it as a fish does water.

The poultryman is the judge of the electric brooder's merits. The cost of operation must be considered. High enough temperatures must be maintained to give proper ventilation.

On a 3-cent rate the cost per chick becomes 3 cents for the season. With the better makes of brooders on the market this figure will be found to be a fair average. During the season of 1928 the current consumption on several brooders near Albany, N. Y., was checked. Two brooders and were of two hundred-chick size, one was three hundred fifty-chick size and one five hundred-chick size. These brooders were well constructed and insulated. Ventilation was provided in the center of the canopy. Open wire coils over the chicks furnished the heat. The brooder was provided with curtains. During March, April and May the average consumption was 0.54 kilowatt-hours per chick. Each user was well satisfied. On another farm similar brooders of cheaper construction and lacking some of the good points of the four mentioned, were used to brood 2200 chicks with a consumption of 1.34 kilowatt-hours per chick.

The following figures were secured on a brooder test at the Oregon Agricultural College:

Cost Per Chick For 8-Week Brooding Period

Brooder	Fuel	Feed	Total Cost per Chick	Mortality (per cent)	
				Barred Rock	Leghorns
	Cents	Cents	Cents		
Lyon Elec.	1.92	5.74	7.66	5.2	8.8
Underheat	1.72	5.41	7.13	17.6	10.0
Oil	3.34	6.08	9.42	8.4	11.9
Coal	2.60	6.94	9.54	14.7	10.0

Electricity 3 cents per kilowatt-hour
Coal $17.00 per ton
Oil 18 cents per gallon
No labor costs included

In figuring advantages we must not forget such items as: labor, freedom from gases and the uniform temperatures. There are no fires to be tended to, three or four times per day. There is no fire hazard. Neither is it necessary to get out of bed about 3 or 4 o'clock in the morning to see if the temperature is right. Cost is of secondary importance if we show lower mortality and stronger chicks. Brooders, in the last analysis, must be judged by the chicks they raise.

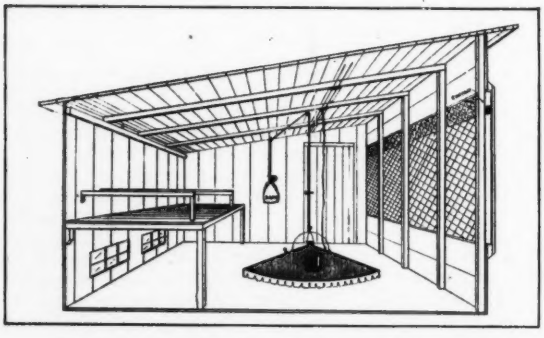
The cold room used in electric brooding is the strongest sales resistance that must be overcome. We must determine how much cold a chick can stand. There is reason to believe that the present accepted temperatures are not correct. Several users report very satisfactory results with chicks when the temperature outside the hover was below freezing. Good ventilation seems to be the factor most essential for cold-room brooding. Moisture and cold together are bad for chicks. However, they seem to thrive on cold alone.

Brooders should have at least 7 square inches of floor space for each chick brooded. There is reasons to believe that more space would be an advantage. The brooder should have long-lived heating coils. The thermostat should be sturdily built with high-melting point contacts; the usual bi-metallic thermostats selling for $2 or $3 will stick after a short time and need replacing.

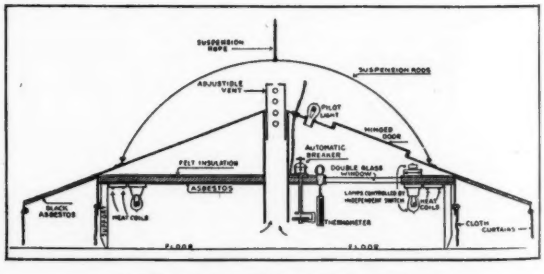
Minor difficulties in electric brooding will be ironed out in practical operation. Farmers are buying brooders from mail order houses. Would it not be better to select some of the better makes, point out their advantages and disadvantages, guide farm customers in their purchases and check on their operating methods?

[1]A contribution to the symposium on rural electrification, presented at a meeting of the North Atlantic Section of the American Society of Agricultural Engineers, at Amherst, Mass., October, 1929.

[2]Rural service specialist, New York Power and Light Corp. Assoc. Mem. A.S.A.E.



An ordinary laying house used for a cold room



Details of patented electric brooder

Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Report on the Absorption of Moisture by Kiln-Dried Lumber, J. H. Jenkins (Canada Department of Interior (Ottawa) Forest Service Circular 23 [1928], pp. 15, figs. 5).—Studies are reported which indicate that the absorption of moisture in kiln-dried lumber in storage is an important problem. Rapid absorption occurs until the moisture content is at equilibrium with the atmospheric conditions. This increase in moisture content results in a corresponding increase in the size and the shipping weight of the stored stock. In cases where seasoned lumber is stored for several months during the winter, there is a danger of the increase in moisture content due to absorption being sufficient to cause checking when the lumber is eventually placed in service in the interior of a heated building. The studies show that there is a very appreciable difference between the absorption of moisture by lumber stored in a tight, heated shed and that stored in an open shed during the seasons of high humidity and low temperatures.

The Bin Method of Drying Seed Corn, A. H. Wright and F. W. Duffee (Madison: Wisconsin University, College of Agriculture, 1929, pp. 12, figs. 5).—The method is described and illustrated.

The Connecticut 20x30 Laying House, R. E. Jones (Connecticut Agricultural College (Storrs) Extension Bulletin 138 (1929), pp. 16, figs. 13).—This poultry structure is described and illustrated.

A Simple Sweet Potato Vine Cutter, J. C. C. Price (Mississippi Station (A. & M. College) Circular 84 (1929), pp. 3, figs. 2).—This device is briefly described and illustrated.

Electric Household Refrigeration, W. T. Ackerman (New Hampshire Station (Durham) Bulletin 244 (1929), pp. 24, figs. 10).—The results of tests of the merits of electric refrigeration in the home made on six farms are reported, which included studies of separate house units and refrigeration in combination with dairy cold storage. The equipment included commercially built cabinet units, common commercially built refrigerators converted to electric operation, and home made refrigerators converted to electric operation. The refrigerators varied in size from 5.5 to 30 cubic feet of food storage space. The combination dairy and household storage represented the lowest investment. Current consumption on five standard type refrigerators averaged 41 kilowatt-hours per month. The average maximum consumption was 67 and the average minimum consumption 13 kilowatt-hours per month. The current consumption for household refrigerators varied from 0.0016 to 0.008 kilowatt-hours per cubic foot of total box capacity. Household storage operated in combination with the dairy required one-third the power used by standard types. The average time of operation of compressor units was 19 per cent of the total elapsed time. Total annual costs for using ice averaged $41.63 per year. The average annual cost of operation of the electric refrigeration was $20.97. Distinctly superior refrigeration was obtained from the electric method.

Rural Electric Service Supplied from Central Stations in Nebraska in 1927, E. E. Brackett and E. B. Lewis (Nebraska Station (Lincoln) Bulletin 236 (1929), pp. 17, figs. 12).—Data are presented and discussed on average annual revenue per consumer in municipalities and private utilities, average revenue per mile on rural service lines, average kilowatt-hours per year per consumer, average revenue per kilowatt-hour, average number of consumers per mile on pole lines serving farms only, average kilowatt-hour consumption per month over two and three-year periods, farm line transmission losses and farm electric equipment.

Cost of Electricity for the Home Electric Refrigerator, R. L. Patty (South Dakota Station (Brookings) Bulletin 241 (1929), pp. 16, figs. 3).—Data are presented on the cost of electricity for home electric refrigeration, together with data on insulation and operation. Four refrigerators used an average of 379 kilowatt-hours of electricity for one year, 3 of these being turned off during the winter. During the 3 warmest months of summer the refrigerators averaged a consumption of 77 kilowatt-hours per month. During the 5 coolest months the average used was 43.6 kilowatt-hours per month. The average temperature maintained by home electric refrigerators was 42.46 degrees (Fahrenheit), which was approximately 10 degrees lower than the temperature maintained in ice boxes tested. An increase of one degree in the weather temperature for a week made the refrigerators under test use about ⅓ kilowatt-hour more electricity for the week. It was found that a favorable location for the refrigerator in the house saves some electricity.

The Use of Electricity on Missouri Farms, R. R. Parks (Missouri Station (Columbia) Bulletin 268 (1929), pp. 47, figs. 27).—A large amount of data obtained on the use of electricity on certain test farms in Missouri are summarized in this publication. The results indicate that the cost of electricity for the farm is dependent first on the cost of operating and maintaining electric lines to the farm and second on the cost of generating electricity and delivering it to the farm over farm lines. It is evident that the first cost remains about the same regardless of the quantity of electricity used. Therefore, no matter what the basis of charge is, the cost per kilowatt-hour of electricity delivered to the farm decreases with the quantity used. According to a typical rural rate used in Missouri, the charge for the first 35 kilowatt-hours used per month was $4.55, for the next 35 kilowatt-hours $1.75, and for the next 130 kilowatt-hours $3.39, making a total of 200 kilowatt-hours and $9.69.

The Combined Harvester-Thresher in North Dakota, A. H. Benton et al. (North Dakota Station (Fargo) Bulletin 225 (1929), pp. 49, figs. 18).—The results are presented of a broadly cooperative study by the station and the U.S.D.A. bureaus of public roads and agricultural economics. These indicate that the maximum moisture content at which wheat may be safely stored is about 14 per cent. The requirements for rye, oats and barley are about the same. For flax the moisture content for safe storage is distinctly lower.

The wheat commonly grown in North Dakota is fairly resistant to shattering. Rye and oats shatter more readily than wheat, as does barley. Barley straw is brittle and heads break off easily when dry. Flax does not shatter, but bolls may drop off, due to insect or rust injury. An increase in the relative humidity of the air usually brings about an increase in moisture content of grain

Immature weed seeds and other fine dockage of high moisture content are frequently present in grain. The excess moisture in such dockage transfers rapidly to otherwise dry grain. Dockage should be removed before the grain is placed in storage.

Wheat combined and stored when dry, unless damaged before threshing, is equally as desirable as wheat harvested with a binder and threshed from the shock. Weathering may affect the weight per bushel of wheat. The flour yield apparently is not affected to the same extent. The protein content does not change, nor does the baking strength of the flour. If the wheat has weathered badly the color may be injured, especially in durum wheat.

Terminal marketing data on 30 cars of combined wheat in 1928 showed slightly over 14 per cent moisture. Similar marketing data on 26 cars of shock-threshed wheat from the same country elevators showed slightly over 13 per cent moisture. A higher moisture content of the combine wheat reduced the grade from No. 1 to No. 2 and lowered the price about 2 cents a bushel as compared to the shock-threshed grain. Grain commission merchants report that combined grain can not be distinguished from other grain.

Removing foreign materials and dockage, mixing damp grain with dry grain, storing in shallow layers or in ventilated deep bins or drying with heated air are the most common methods that may be helpful in preventing damage to grain in storage.

The germination and milling and baking qualities of wheat were apparently not affected by artificial drying with heated air at a temperature of 160 degrees (Fahrenheit). The rate at which grain is dried has no appreciable effect on the maximum weight per bushel. The cost of the fuel required to dry grain artificially was small in comparison with the net increase in market value from drying.

In the combine studies it was found that loss of grain in the head is due to improper cylinder and concave adjustment. The cracking of grain is caused by insufficient clearance between cylinder and concave teeth, excessive speed of cylinder, excessive tailings, or end play in the cylinder. The secret of clean and efficient separation lies in the operator's ability to prevent overloading the sieves.

The average acreages harvested by the different sizes of combines were found to be slightly over 500 acres for the 10 and 12-foot, 717 for the 15-foot, and 1,296 acres for the 20-foot.

The average acreages harvested per day were found to be 25 acres for the 10-foot combine and 30 acres for the 16-foot combine. The 12 and 16-foot windrowers averaged 48 and 55 acres per day, respectively.

The man labor involved in harvesting with the combine is

approximately one-fourth the amount required in the binder-thresher method. The combine owner is thus practically independent of transient labor for harvesting.

The cost of direct combining, exclusive of depreciation, interest on the combine and overhead, averaged 93 cents per acre for the 16-foot and $1.03 for the 10-foot. The acreage harvested per season materially affects the total cost per acre due to the varying depreciation and interest charges.

On the basis of 600 acres, the total cost of harvesting with a 16-foot combine averaged $1.52 per acre when direct combined and about $2 when the windrow pick-up method was used. When harvesting and threshing this acreage with three 8-foot binders and thresher, the total costs averaged $3.32 per acre and $3.26 if only two 8-foot binders were used On the basis of 500 acres the total cost of direct combining with the 10-foot machine amounted to $1.54 per acre.

Seven Years' Experience with the Combined Reaper-Thresher, 1922-1928, J. G. Taggart, J. K. MacKenzie, and E. S. Hopkins (Canada Department of Agriculture (Ottawa) Bulletin 118, new series (1929), pp. 27, figs.11).—The detailed results of seven years' experience with the combine at the Swift Current, Sask., Experimental Station are presented and discussed. These indicate that on the average wheat farm the introduction of a combine does not necessarily entail any drastic change in farm practices. In general the methods that have proved profitable in grain farming when the crops were harvested by the binder and separator will be found quite suitable when farming for the combine. A crop which is free from weeds and matures uniformly is highly desirable when the combine is used.

One outstanding result of the introduction of a combine on a farm is that the peak load of work is transferred from the fall to the spring. The combine largely eliminates the necessity for a large crew in the harvest season. Owing to the increased necessity for early maturity, it enhances the desirability of early seeding, and thus it has been a motive behind the increased demand for one-way disks, larger disk harrows and wide seed drills. The combine has also been a factor in increasing the number of medium-powered tractors.

The Oregon Apple-Washer, H. Hartman (Oregon Station (Corvallis) Circular 92 (1929), pp. 4, figs. 4).—An apple-washing machine developed by the Oregon Experiment Station is described and illustrated. It is of the flotation type and consists essentially of a two-compartment tank, one compartment for the washing solution and another for the rinse or fresh water bath. The fruit is propelled on the surface of the liquid by paddle wheels and is lifted out by endless-chain elevators.

Life, Service and Cost of Service of Farm Machinery, J. B. Davidson (Iowa Station (Ames) Bulletin 260 (1929), pp. 257-275, figs. 4).—The results of a study are reported which indicate that the average life of farm machines on Iowa farms varies from 8 years for spring-tooth harrows to 24 years for the farm wagon. An average life for all machines is 15.2 years. The life of individual machines was found to vary much from the average. The average life of grain binders, for example, was found to be 16 years, but machines were encountered which lasted only 5 years, while others had a life of 33 years. The average annual service of farm machines in days of actual use is very low, varying from 4 days for the seeder to 80 days for the wagon and gasoline engine. The average annual use of all farm machines is 16 days. With few exceptions, the life of farm machines is not directly influenced by the number of days used per year. The annual cost of repairs was found to vary from 0.5 per cent of the first cost for the roller, seeder and spring-tooth harrow to 5 per cent for one-row cultivators. The average cost of service for one day varies from 8 cents for the one-row cultivator to $10.11 for a silage cutter. It appears that the total annual cost of a farm machine varies from 12 to 21 per cent of the first cost. While the housing of farm machinery is desirable, systematic repairing has more influence on its life. Apparently the most important factor in reducing the cost of each day's service is a large number of days of use per year.

Essentials of a Mulch Paper Laying Machine, H. H Musselman (Michigan Station (East Lansing) Circular 126 (1929), pp. 7, figs. 3).—The essential features of a machine for laying mulch paper are briefly described and illustrated and a bill of materials included.

Effect of Temperature on Bacterial Numbers in Digesting Sewage Sludge, H. Heukelekian and W. Rudolfs (Journal of Bacteriology (Baltimore), 17 (1929), No. 4, pp. 247-254, figs. 4).—In studies conducted at the New-Jersey Experiment-Stations sewage solids subjected to different temperatures were insulated with and without additions of lime. Total bacterial counts were made and the approximate numbers of different physiological groups determined. The average number of the different groups of organisms was not affected by different temperatures, except in the case of hydrogen sulfide producers, but the addition of lime influenced the average numbers. A wide divergence was found between total numbers of lactose formers and spore-forming lactose fermenters. With increase in temperature the divergence became smaller, so that at the higher temperatures employed the spore-forming lactose fermenting organisms constituted the majority of the lactose fermenting organisms, while the total numbers of organisms (plate counts) were greatly reduced.

Cement Concrete Posts for Fencing, W. J. Spafford (Journal Department of Agriculture of South Australia (Adelaide), 32 (1929), No. 7, pp. 612-623, figs. 8).—Information is given on the design and manufacture of cement concrete fence posts, together with working drawings of forms, wire attachments, and methods of reinforcing.

Sewage Disposal for the Farm Home, R. C. Kelleher and E. W. Lehmann (Illinois Station (Urbana) Circular 336 (1929), pp. 20, figs. 19).—This circular describes a simple, effective, and inexpensive method of disposing of farm sewage and includes directions for planning and construction, together with a bill of materials for the concrete forms required.

Fuels for Cooking Purposes in Rural Homes (Indiana Station (La Fayette) Report, (1928), pp. 16, 17).—The results of a survey of fuels used for cooking purposes in 1,400 rural homes in Indiana are briefly summarized.

Farm Power and Labor, H. B. Josephson and R. U. Blasingame (Pennsylvania Station (State College) Bulletin 238 (1929), pp. 20, figs. 9).—The results of two years of preliminary study of the power and labor requirements of Pennsylvania agriculture and how they may be profitably reduced by engineering procedure are summarized in this bulletin.

From a study of a two-plow general-purpose tractor, it was found that the average cost per hour for using the tractor during two seasons, at all kinds of farm work, was 84 cents. The average cost per hour for fuel, oil and grease was 34 cents, leaving 50 cents for fixed charges. These figures do not include the operator's time.

When rocks did not interfere appreciably, plowing with the tractor was done with 1.7 man-hours per acre at a total cost of $2 33, while it required 5 man-hours and cost $3.80 per acre to plow similar land with teams and walking plows. To plow moderately stony fields with the tractor took 2.9 man-hours and cost $3.47 per acre, while plowing very stony fields required 3.6 man-hours and cost $4.07 per acre when using the tractor. When using teams and walking plows, rocks did not appreciably affect the time required or the cost of plowing.

The greatest saving in labor and expense through the use of the tractor was in seedbed preparation. In spring-tooth harrowing, for example, 0.27 man-hour per acre was required when using the tractor, 0.43 man-hour when using four horses, and 0.8 man-hour when using two horses. The cost per acre was 39 cents when using the tractor, 53 cents with four horses, and 62 cents with two horses. In drilling grain, cultivating corn and potatoes, moving hay and cutting grain, considerable labor was saved through the use of the tractor, but the cost was not apreciably reduced.

No labor was saved in planting corn, spraying potatoes, spreading manure or digging potatoes with the tractor as compared with using common Pennsylvania practices, and the cost was slightly higher when the tractor was used.

In plowing stony ground with tractors it is important to use a spring-release hitch that may be quickly and easily rehitched from the operator's seat.

The cost of clearing typical limestone land with dynamite was $35 to $53 per acre. This expense is justified only when the potential money value of the crops produced is high.

The combine method of harvesting wheat reduced the labor from 8.5 man-hours per acre to 2.7 man-hours when the straw was left in the field. There was also considerable saving in cost. Considerable labor was saved, even when the straw was removed, but the cost was then higher than for the the binder and thresher method. Similar results were obtained with oats. The future of the combine harvester in Pennsylvania depends on the development of a satisfactory method of saving the straw and of suitable equipment for drying the grain.

Picking potatoes behind an elevator digger required nearly one-third of the total man labor in producing the crop. This is entirely a hand operation and there is need for labor-saving machinery in potato harvesting.

[Agricultural Engineering Investigations at the Michigan Station] (Michigan Station (East Lansing) [Biennial] Report 1927-28, p. 5).—Limited trials of the use of chromium plating on the wearing surfaces of tillage tools showed that the plating chips at the cutting edge and thus exposes the steel to weathering processes and to rust. It is concluded that present methods of chromium plating are not adapted to farm machinery.

Data are also briefly reported on a new marl excavating bucket, the combine in Michigan and the farm use of electricity.

Who's Who in Agricultural Engineering

Hickman Price

M. A. R. Kelley

E. S. Patch

J. W. Carpenter, Jr.

Hickman Price

Hickman Price (Mem. A.S.A.E.) is a leader in the field of large-scale agricultural production. After graduating from Columbia University in 1909 he commenced the agricultural development of land in Northwest Texas. Continuously during the last twenty years he has enlarged these operations until they now comprise thirty thousand acres lying in four tracts within a radius of eighty-five miles of Amarillo, Texas. In addition to directing this farming enterprise, he has been a newspaper publisher and editor. Later, for eight years, he was associated with the motion picture industry, but since 1928 has given himself exclusively to his large-scale farming operations. His headquarters are in the Fisk Building, Amarillo, Texas. He spends part of each year at his home in Bronxville, New York. At the A.S.A.E. Power and Machinery Division meeting in Chicago, December, 1929, he presented a paper entitled "Trends in Large-Scale Wheat Farming." (AGRICULTURAL ENGINEERING, Vol. 11, No. 2, February, 1930.) He has been a member of A.S.A.E. since 1927.

M. A. R. Kelley

Manley Alexander Raymond Kelley (Mem. A.S.A.E.) is agricultural engineer in the division of agricultural engineering, Bureau of Public Roads, U. S. Department of Agriculture. After receiving his bachelor's degree in mechanical engineering at Iowa State College in 1912 he went to the University of Missouri as assistant in agronomy in charge of rural architecture and farm machinery. In 1913 Iowa State College granted his bachelor's degree in agricultural engineering. He organized and was in charge of the first agricultural engineering department at the University of Missouri, but left in 1916 to take charge of the building plan service of the Louden Machinery Company. Since 1918 he has been with the U. S. Department of Agriculture in the farm building research work in the Division of Agricultural Engineering. As a member of the A.S.A.E. since 1913 he has been particularly active in its farm structures work, presenting papers at meetings, contributing articles to AGRICULTURAL ENGINEERING and serving on farm building equipment, farm building ventilation, grain storage and other committees. He has also served on the Standards Committee and as a vice-president of the Society. Twelve of his papers, probably more than of any other one author, are published in the Transactions of the Society.

E. S. Patch

Earl Stone Patch (Mem. A.S.A.E.) has been vice-president in charge of engineering and sales for the Moraine Products Company, a subsidiary of General Motors Corporation, since it was organized in 1925. After studying mechanical engineering for two years at Purdue University he entered engine and truck testing, research and development work in the first engine laboratories of the General Motors Corporation. After five years he resigned, in 1916, to become chief engineer for the Reliable Engine & Tractor Company of Portsmouth, Ohio. In 1917 he joined the Moline Plow Company as chief inspector of the tractor works and remained there until, in 1920, he returned to the General Motors organization as engineer of tests in its Samson Tractor Division. In this position he developed field and laboratory test methods for measuring power and performance characteristics of implements and tractors and studied the requirements of the general-purpose tractor. Transferred to the General Motors Research Corporation in 1922, he assisted in the development of a general-purpose tractor and was at the same time in charge of the writing of reports on the general research of the organization. It was from this work that he was transferred to his present position in 1925.

J. W. Carpenter, Jr.

John Wilson Carpenter, Jr., (Mem. A.S.A.E.), chairman of the Southern Section of A.S.A.E., is agricultural engineer in charge of the division of agricultural engineering of the Mississippi Agricultural Experiment Station. He became an agricultural engineer by earning his bachelor's degree in civil engineering at Mississippi A. & M. College in 1912, returning immediately to complete requirements for a bachelor's degree in agriculture in 1914, and continuing his studies that summer in the agricultural engineering department at Iowa State College. He has since spent another summer at Iowa State, working toward his master's degree. From the fall of 1914 until 1917 he was extension specialist in the agricultural engineering department of his alma mater; then was a county agent until 1920; during the latter year managed a highway hauling company; returned to county agent work; in 1923 was made associate professor of agricultural engineering at Mississippi A. & M. College; and when the division of agricultural engineering was organized in the Mississippi Agricultural Experiment Station a few years ago he accepted his present position. He is co-author of several extension bulletins and has served on A.S.A.E. committees on cost of production, farm crops and land drainage.

AGRICULTURAL ENGINEERING

Established 1920

A journal devoted to the advancement of the theory and practice of engineering as applied to agriculture and of the allied arts and sciences. Published monthly by the American Society of Agricultural Engineers, under the direction of the Publications Committee.

PUBLICATIONS COMMITTEE

G. W. Iverson, Chairman

F. A. Wirt R. W. Trullinger

P. S. Rose C. O. Reed

The Society is not responsible for the statements and opinions contained in the papers and discussions published in this journal. They represent the views of the individuals to whom they are credited and are not binding on the Society as a whole.

Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

Original articles, papers, discussions, and reports may be reprinted from this publication, provided proper credit is given.

RAYMOND OLNEY, Editor

R. A. Palmer, Assistant Editor

The Professional Course Enrollment Situation

A RECENT survey of college agricultural engineering departments revealed the startling information that only three of them are graduating men from their professional courses in any significant number. Kansas, Virginia and Iowa together expect to graduate this year thirty-one bachelors of science in agricultural engineering. The other eighteen schools offering the professional course expect to graduate a total of sixteen bachelors of science in agricultural engineering. In about half of these eighteen schools the professional course is so new there has not yet been time to build up a substantial enrollment. In the remainder of this low enrollment group, however, are departments with professional courses older than those at Virginia and Kansas.

Why this low output from some agricultural engineering departments? Certainly it is due to no lack of demand for well-trained agricultural engineers. Other college agricultural engineering departments and commercial interests are literally gasping for them. It seems doubtful if any state which once saw the need of agricultural engineers sufficiently to provide for a professional course could have changed its attitude, considering the service the new profession has already rendered in all the states where it has been given any encouragement.

Apparently there is more diversion of resources and attention to other activities than is justified. A young profession, like an army when war is impending or just started, should be devoting its principal attention to the training of recruits. There are distracting demands it is true, and many of them must be met. But the fact that a few departments have, while meeting them, maintained and built up the enrollment in their professional courses, suggests that other departments might, by dint of great effort, do likewise.

It looks much as if some departments, after having successfully initiated a professional course, have taken enrollment for granted. That cannot safely be done while our profession is still so young. Farm boys who have operated modern farm machinery or who have otherwise seen a few of the advantages of the application of engineering to agriculture—the very group from which the agricultural engineering profession must recruit—are graduating from high schools, many of them without knowing what opportunities the agricultural engineering profession offers, that training for it may be within their reach, or that such a profession even exists. Consequently many potential agricultural engineers either fail to continue their education or continue it along other lines.

Preliminary steps in that direction have been taken, but whether or not the A.S.A.E. will soon be able to make available a booklet of vocational guidance, with particular reference to the agricultural engineering profession, the situation warrants the attention of every agricultural engineering department offering or comtemplating a professional course. We are not begging support for the profession. It can stand on the strength of its justification. We do believe that the attention which a college department gives to professional training is a reliable measure of its virility.

Engineering Considerations of Soil Depletion

IT HAS become platitudinous to say that the soil on American farms is being depleted and that the problem deserves more attention than it is getting. These are generally known facts. But C. A. Bacon, in his paper on the "Relation of Farm Machinery to Maintenance of Soil Fertility," published in this issue, has gone further and clearly pointed out the responsibility of agricultural engineers in that connection.

Tractor power and modern tillage tools are speeding up soil depletion. The increased tillage which they have made possible makes plant food available more rapidly, to be carried away in crops and erosion unless precautions are taken. Furthermore, they have made it possible to temporarily offset lower production per acre with lower costs per acre, and have led farmers to look to increased acreage as a means of maintaining production in spite of decreasing fertility.

While larger fields than were current in the horse power age are now desirable, increased size is no substitute for fertility. McKibben has analyzed the effect of width, operating speed and interruptions on the effective capacity of field machines in terms of acres covered (AGRICULTURAL ENGINEERING Vol. 11, No. 2, February 1930, Page 55). Consider the nature of yield as a fourth factor influencing acre-capacity. It is obvious that it has no influence on seedbed preparation and only an indirect influence, if any, on the rate of cultivation of row crops. Its principal influence is on the capacity of harvesting machines. But decreased yield does not increase the acre-capacity of even harvesting machines proportionately. They must be made with capacity to handle substantial yields. Operating width and speed are relatively fixed and cannot be increased to compensate for low yields. It must be concluded, and it is borne out by scientific research as well as common experience, that yield is a minor factor in the acre-capacity of field machines and a minor influence on the acre-cost of producing crops. A reciprocal statement of this conclusion is that the time required for machine operations and the cost per crop unit produced under a given set of conditions is roughly proportional to the area required to produce it.

A hoe is a less expensive tool than the most modern tractor-drawn outfit for tilling soil reduced to an unresponsive, barren waste. The greatest advantage of a set of modern field machinery is shown when the soil and other conditions are right for raising the largest and highest quality crops possible on the acreage it can cover. In addition to the yield item and its effect on production costs, high fertility minimizes the effect of unfavorably weather conditions and has a direct bearing on the quality and ease of handling of farm crops. To the extent that modern farm machinery is allowed to contribute to wasting fertility it defeats its purpose.

A. S. A. E. and Related Activities

College Division Advisory Committee Reports on Washington Meeting

THE Advisory Committee of the College Division of the American Society of Agricultural Engineers met on April 14 to 16 at Washington, D. C., at the headquarters of the Division of Agricultural Engineering, U. S. Department of Agriculture. Members of the committee, all of whom were present, are Professors E. R. Jones, Chairman (Wisconsin), S. P. Lyle (Georgia), H. W. Riley (New York), F. C. Fenton (Kansas), and C. E. Seitz (Virginia).

Principal activities of the Division of Agricultural Engineering and the relations between that division and the colleges and among the colleges were discussed. The need for correlation and coordination of the research activities of the different institutions was the key-note of this discussion. The influence of the Davidson and Walker reports upon research on mechanical farm equipment was noted as being marked and favorable upon the quality and quantity of research in that subject by the colleges. A report of progress in the survey of research in farm structures listed only forty-three projects under way in nineteen colleges, and some of these were inactive during the current year. A projected service by the Division of Agricultural Engineering of preparing and distributing a card index to agricultural engineering literature was outlined.

Another subject discussed was the practicability of establishing fellowships in teaching methods to encourage definite preparation for teaching farm conveniences, farm structures and farm machinery, and to prepare men to become leaders in each of these fields. It was proposed that these fellowships be financed principally, of necessity, by the industrial groups interested, but that they be administered by the colleges. By invitation of the chairman representatives of the National Electric Light Association and the National Lumbermen's Association were present and participated in the discussion. The preparation of detailed outlines for the establishment of such fellowships in the various subjects is to be undertaken by the Committee.

A program for a school in methods of extension work for extension workers in agricultural engineering, to be held June 11 to 14 at Urbana, Illinois, was heartily endorsed by the Committee. The plan was presented to the Committee on Extension Organization and Policy of the Land Grant College Association, then meeting in Washington, and was approved by that committee and by the director of extension work of the U. S. Department of Agriculture. Plans for a school for agricultural engineering instructors, to be held June 23 to 26 at Madison, Wisconsin, immediately following the annual meeting of the American Society of Agricultural Engineers at Moline, Illinois, were presented by Professor E. R. Jones and endorsed by the Advisory Committee.

The essentials of the college graduate's letter of application in seeking employment, the character and importance of the Confessor, and the encouragement of student branches of A.S.A.E. were among the subjects receiving attention. Last year's plan for the Confessor was commended. The program for the meeting of the College Division at the annual meeting of the Society in June was discussed briefly, and progress reports of the standing committees were presented.

Demand for high-quality men in agricultural engineering positions still far exceeds the supply, it was stated. The requirements of the curriculum for agricultural engineering were discussed, as were the problems of administration in relation to engineering schools, and means of attracting more men of ability to agricultural engineering courses. The formulation of minimum standards for professional agricultural engineering training was adopted by the Committee as an important objective for the coming year. The preparation of a booklet setting forth the opportunities of agricultural engineering was endorsed.

An outline for an extension project in rural electrification was presented by Professor Seitz. Distribution of this project outline by the Department of Agriculture to all the state colleges was recommended by the Committee. The organization and method of operation on the six federal experimental soil erosion farms was described, where control of erosion is handled as a problem of land drainage and moisture conservation.

Reorganization of the committees of the College Division was discussed. It was recommended that the committee on cooperative relationships be discontinued, and that the committee on student branches of the Society be made a committee of the College Division.

Dates Set for North Atlantic Section Meeting

THE North Atlantic Section of the A.S.A.E. has decided to hold its next meeting at Rochester, N. Y., on October 16, 17 and 18. B. B. Robb of the agricultural engineering department at the New York State College of Agriculture is chairman of the Meetings Committee which is already busy planning for the professional interests, comfort and entertainment of the Section members at the three-day gathering.

L. S. Caple, rural service engineer for the Rochester Gas and Electric Corporation, is in charge of local arrangements. The North Atlantic Section is one of the largest and most active in the Society. In October, 1929, it held a highly successful three-day meeting at Amherst, Massachusetts.

Housing to be Considered at Home Economics Meeting

HOUSING is an important subject on the program of the American Home Economics Association meeting to be held at Denver, Colorado, June 24 to 28. John Nolen, nationally known architect of Cambridge, Massachusetts, will be the speaker at one of the general sessions and has chosen to talk on "Housing for the Modern Family."

At another session especially devoted to the house there will be a discussion of urban and rural trends in the housing problem and of equipping and furnishing the house.

Eloise Davison, home economics advisor, National Electric Light Association, who will incidentally represent the American Society of Agricultural Engineers at the meeting, is on the program to present a paper on "Electricity in the Institution Kitchen," and also to contribute a discussion on "Improvement of Research by Training of Workers."

Coordination of Agricultural Engineering Progress in Germany

GERMANY is successfully coordinating all efforts to promote agricultural engineering progress in that country through the "National Committee for the Advancement of Technic in Agriculture," according to Otto Schnellbach (Aff. Mem. A.S.A.E.), assistant secretary of the committee. "Reichskuratorium fur Technic in Der Landwirt-

shaft" is the German name for the committee, which is abbreviated "R.K.T.L."

German agricultural authorities have been quick to realize that power and labor represent 40 to 50 per cent of their farm production costs. In their agricultural crisis since the war they have directed research particularly toward the saving of man and animal power. Their various research organizations began producing a great number and variety of valuable data. But the only available medium of exchange of experiences and data between researchers and research organizations was the agricultural press. Reports in books and periodicals referred only to finished projects. Wasteful duplication of effort naturally resulted. Also the data produced remained buried in reports instead of being made widely known and applied. To make matters worse the agricultural departments of the government were besieged with requests for support for various researches and by suggestions from farm machinery manufacturers for solving agricultural problems through technical improvements. To correct the situation the German Ministry of Agriculture a few years ago established the R.K.T.L., a technical "farm board" of 185 members. A secretary and staff handle the executive work. Without itself conducting any research it serves as a clearing house for information on agricultural research and for the handling of public or private research funds.

Applications for financial support are carefully investigated and the proposed research considered in relation to other researches proposed, under way and finished. Researchs receiving support through the committee bind themselves to report fully in writing the results of their work. The R.K.T.L reserves the right to make public results or partial results, giving credit to the author. Equipment purchased from funds administered by the committee remains its property. Committee members and researchers with permanent positions give their time without compensation. Full-time managers and assistants are frequently hired and paid to conduct a particular investigation.

Agricultural engineering investigations which have been made possible by and conducted under the auspices of the committee include a test of the combine-harvester in Germany; and a test of milking machines which resulted in making improved machines available at lowered prices. Also the committee has helped to finance public and semi-public extension work to interpret and carry the results of research to farmers.

American Engineering Council

THE administrative board held its annual spring meeting in Washington May 12 and 13 and wave consideration to a number of reports.

An unprecedented number of bills involving engineering considerations have been presented in the current session of Congress. Council's Public Affairs Committee has given consideration to bills on the following subjects, among others: Moving expenses of civilian employees of the Federal government; rivers and harbors; air transport service; foreign commerce; Ft. Wayne barge canal; Bureau of Public Roads; engineering experiment stations; express motorways; Great Lakes-St. Lawrence waterway; immigration; Inland Waterways Corporation; Lighthouse Service; Government employees' medal of honor; mobilization of resources in time of war; motor vehicles; National Reclamation Control Service; Nicaraguan Canal; oil pollution; and Steamboat Inspection Service. It is also giving attention to the impending reorganization of the Federal Power Commission.

President Grunsky and Executive Secretary Wallace have filled and are scheduled to fill a number of speaking engagements in the winter and spring months. Following its practice of cooperation with organizations with similar interests Council has been represented in the past few months at meetings of the American Academy of Political Science; American Society of Mechanical Engineers; Business Papers Correspondents Committee; Communications Committee, American Bar Association; Federal Board of Surveys and Maps; L'Enfant Memorial Association; Rosenwald Museum of Engineering and Industry; National Bureau of Economic Research; National Council on Street and Highway Safety; Planning Committee, Division of Simplified Practice; Case School of Applied Science; and the Joint Committee of Ten, Washington-Potomac Canal.

When detailed plans for the taking of the current census were under consideration Council protested the plan for classifying all professional engineers as either civil, electrical, mechanical or mining engineers. To more accurately group engineers according to the type of work done it suggested eleven classifications. The original plan of the Census Bureau, however, was not modified, for the following reasons:

1. Past censuses have only included the four above mentioned classifications and therefore additional classifications would render comparative studies with the former census more complicated and difficult.
2. The Census Bureau places greatest emphasis upon and desires to know primarily how the people of the country earn their living and not what particular professional groups they belong to or care to be classed in.
3. Additional classifications materially increase the clerical work and expense.
4. The Bureau declined to adopt any classification which it is reasonably sure would not contain more than 5,000 individuals.

American Engineering Council has had in process for a year an analytical census of the membership of engineering and allied technical societies. This study when completed, will give one of the most comprehensive cross-sections of the profession yet obtained. It will not cover every professional engineer but it will include over 130,000. The results of this study will probably be more significant and valuable than those of the Census Bureau because of the restrictions the Bureau had to place on its survey.

Necrology

HAROLD TAGGART MURRAY, vice-president and western manager of the Case-Shepherd-Mann Publishing Corporation, died in Chicago April 29. Since joining that organization in the fall of 1926 and working on its publication, "Electricity on the Farm," he had become a prominent personality in the field of rural electrification.

He was born at Bradford, Pennsylvania, in 1893; studied at the University of Pennsylvania and received his bachelor's degree in economics in 1915; was secretary and assistant to the president of Drexel Institute from 1914 to 1916; then engaged in commercial sales and advertising work in New York until 1919; was next sales manager for Certainteed Products Corporation for three years; and then was sales manager for the Foamite-Childs Corporation until joining the publishing company. In his untimely death rural electrification has lost an active and enthusiastic supporter and a pleasing personality.

Personals of A.S.A.E. Members

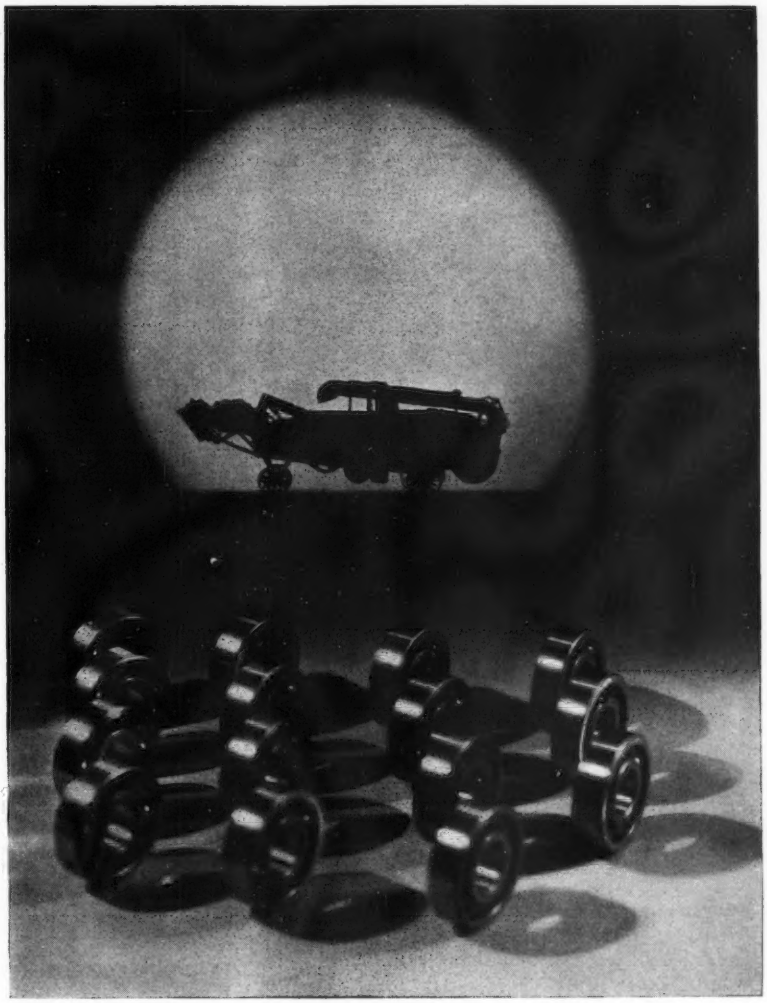
Hobart Beresford, secretary and project director of the Idaho Committtee on the Relation of Electricity to Agriculture, (Moscow), has just issued Progress Report No. 6, reporting the cooperative studies of the application of electricity to agriculture and the progress of rural electrification in Idaho for the year 1929. The report is quite exhaustive, containing 125 mimeograph pages.

F. W. Knipe has resigned as extension agricultural engineer of Connecticut Agricultural College, to become associated with the International Health Division of the

NEW DEPARTURE BALL BEARINGS

Cyclone Cellar Security from Dust and Chaff

This menace enveloped old-time threshers, absorbed the oil and entered the bearings, causing premature wear and trouble. Now . . . New Departure Ball Bearings and their dust-proof housings. Grease - lubricated only once a year, these modern foes of friction and wear perform smoothly without further care. They attract attention only by what they save the farmer . . . that daily oiling job . . . preventing costly breakdowns in the rush of a busy season . . . by the longer, useful, efficient life which they give the entire mechanism. ● The reasons for and logic of this superior bearing performance are summed up in this self-evident fact: Nothing rolls like a ball. ● The New Departure Mfg. Co., Bristol, Conn.



These threshers and combines are the better for New Departure Ball Bearings : Avery Case McCormick-Deering Advance-Rumely John Deere Gleaner-Baldwin

1549

NOTHING ROLLS LIKE A BALL

Rockefeller Foundation. He will be engaged in research work in drainage as it influences malaria fever, in Bulgaria, Italy, France and Germany. His permanent address will be 20 Rue de la Baume, Paris(Ville), France.

W. H. Worthington (recently elected first vice-president of A.S.A.E.) has resigned as chief engineer of the Gleaner Combine-Harvester Corporation to accept a position as research engineer with the John Deere Company, Waterloo, Iowa.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the May issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Franklin D. Fulton, assistant agricultural engineer, U. S. Department of Agriculture, Toledo, O.

W. F. Heesch, general manager, French & Hecht, Inc., Davenport, Ia.

C. N. Hinkle, instructor, Purdue University, Lafayette, Ind.

Ivan A. Karmanoff, mechanical engineer, Amtorg Trading Corp., New York, N. Y.

Lamar M. Kishlar, consulting engineer, Ralston Purina Co., St. Louis, Mo.

C. H. Moran, sale promotion manager, Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa.

Vernon E. Parrish, orchardist, Box 33, Cupertino, Calif.

George O. Sanford, reclamation economist, Bureau of Reclamation, Washington, D. C.

Harry W. Trump, sales engineer, Timken Roller Bearing Co., Canton, O.

Edward T. Wilson, agricultural engineer, Pennsylvania Power and Light Company, Allentown, Pa.

Transfer of Grade

J. W. Slosser, special salesman, John Deere Plow Co., Kansas City, Mo. (Student to Junior Member.)

New A.S.A.E. Members

Joy E. Badley, agricultural sales department, Caterpillar Tractor Company, San Leandro, Calif.

Charles H. Brown, president, Brown Tool Co., Inc., Breckenridge, Tex.

Ellis G. Diseker, assistant agricultural engineer, Alabama Polytechnic Institute, Auburn, Ala.

Marvin B. Fox, farmer, Waukee, Ia.

John S. Franco, manager tractor department, National Brake & Electric oC., Milwaukee, Wis.

William E. Ghent, secretary, Boggs Mfg. Corp. and Boggs Plow Co., Inc., Atlanta, N. Y.

William H. Gregory, Jr., assistant extension agricultural engineer, Alabama Extension Service, Auburn, Ala.

Joseph E .Murphy, production manager, The Minneapolis Tribune, Minneapolis, Minn.

Hickman Price, Jr., farmer, Amarillo, Tex.

Bertram E. Skinner, assistant advertising manager, J. I. Case Company, Racine, Wis.

Wallace A. Thexton, rural service department, General Electric Supply Corp., St. Paul, Minn.

Ben G. Van Zee, research fellow in agricultural engineering, Iowa State College, Ames, Ia.

John B. Wilson, extension agricultural engineer, Alabama Polytechnic Institute, Auburn, Ala.

Transfer of Grade

John W. Randolph, assistant professor, Alabama Polytechnic Institute, Auburn, Ala. (Associate Member to Member.)

Employment Bulletin

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only Society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available' section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested. Copy for notices must be received at the headquarters of the Society not later than the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. There is no charge for this service.

Men Available

AGRICULTURAL ENGINEER, export specialist, member of A.S.A.E. Formerly government export and import expert in Russia and Yugoslavia. Eight years experience in traveling all thoroughly acquainted with all phases in export and trade of farm machines, implements, fertilizer and chemical specialties used in farming in Russia, Yugoslavia, Bulgaria and Albania. Speaks Russian, Serbian, Croatian and Bulgarian languages fluently. Has energy, ability and wide knowledge in research, new markets and organizing sales promotion work in countries mentioned. Russian born, American citizen, 32. Married. Wants connection in a manufacturer's export department. Willing to go anywhere. MA-168.

AGRICULTURAL ENGINEER, bachelor's degree from Wisconsin, 1927, master's degree from Rutgers University, 1930, Illinois farm background, one and one-half years corn borer control research, one summer Wisconsin State soil survey, two and one-half years as assistant instructor; knowledge of farm machinery, buildings, drainage and insect control machinery. Desires position as research worker or teacher. Age 26. Single. MA-175.

AGRICULTURAL ENGINEER, with master's degree in agricultural engineering from University of Nebraska, desires position in teaching, research or extension work in agricultural engineering in a land-grant institution. Born and raised on a Nebraska farm and has had extensive experience in agricultural engineering work. 38 years old, in good health, married, two children. MA-176.

AGRICULTURAL ENGINEER, master's degree in agricultural engineering from midwestern university, three years experience teaching farm machinery, dairy mechanics and physics, knowledge of buildings and land reclamation, desires position as research worker or teacher. Age 27. Single. MA-177.

AGRICULTURAL ENGINEER with several years experience in farm building design with barn equipment and ventilating concerns desires a position requiring part time outside or field work with a college experiment station in farm buildings work, or with a barn equipment and ventilating concern. Location in middle west preferred. College graduate, age 38, married. MA-178.

Positions Open

JUNIOR ENGINEER wanted by eastern utility for electric power sales in rural communities, including small commercial developments. Should have an agricultural background and be a graduate of a recognized technical college. Good opportunity for advancement. Please enclose recent picture and state age, education, experience and salary desired. PO-170.

AGRICULTURAL ENGINEER wanted to fill a position in part time residence and part time extension work in the agricultural engineering department of a land-grant university. A graduate in agricultural engineering qualified to handle farm buildings, farm shop, rural sanitation and machinery is desired. PO-171.